JAN 9 1926

Medical Library

Volume VIII JANUARY, 1926 Number 1

THE JOURNAL OF INDUSTRIAL HYGIENE

AND ABSTRACT OF THE LITERATURE

Official Organ of The American Association of Industrial Physicians and Surgeons

Editor, United States
DAVID L. EDSALL, M.D., S.D.

Honorary Consulting Editor
SIR THOMAS M. LEGGE, M.D., D.P.H.

Editor, Great Britain
E. L. COLLIS, M.D., M.R.C.S.

Prevention and Treatment of Stiffness after Fractures

The Thermal Index of Atmospheric Conditions and its Application to Sedentary and to Industrial Life

The Treatment of Industrial (Surgical) Accidents with a View to Restoration of Function and Minimizing Subsequent Incapacity: A Plan for Large Employers of Labor for Dealing with Such Accidents

The Oxygen-Carbon Dioxide Treatment of Carbon Monoxide Poisoning: Communication from Dr. J. S. Haldane

Published Monthly at Mount Royal and Guilford Aves., Baltimore, Md.
by HARVARD MEDICAL SCHOOL

Entered as second-class matter, at the Post Office at Baltimore, Maryland, under Act of March 3, 1879. Published Monthly.
Copyright, 1926, by Harvard Medical School.

Made in United States of America

Wanted

Copies of **The Journal of Industrial Hygiene** for May, 1919, June, 1919, December, 1919, and May, 1921.

For copies of the May, June, and December, 1919, issues in good condition $1 each will be paid; for copies of May, 1921, 75 cents.

Persons wishing to sell copies of these issues are requested to communicate with

Managing Editors

Journal of Industrial Hygiene

55 Van Dyke Street

Boston, Mass.

THE JOURNAL OF INDUSTRIAL HYGIENE

PUBLISHED MONTHLY

VOLUME VIII JANUARY, 1926 NUMBER 1

PREVENTION AND TREATMENT OF STIFFNESS AFTER FRACTURES*

WILLIAM T. JOHNSON, A.B., M.D.

Philadelphia, Pa.

THE measures here advocated for the prevention and treatment of stiffness after fractures are not new, nor equally applicable in all cases, but their more frequent use will hasten recovery and add to the comfort of the patient.

X-RAY STUDY

It is today unsafe to treat any case of suspected fracture without the aid of X-ray study. When the injury is near a joint this study should be most painstaking, for the roentgenologists report that as their technic and interpretation improve fewer sprains are found and more fractures shown. This is of the utmost importance, as in injuries involving joints ankylosis may result from deposition of inflammatory exudate or excess callus formation, either or both of which would be favored by early motion.

ELIMINATION OF POSSIBLE SOURCES OF INFECTION

Stiffness after fractures is not infrequently due to some unsuspected systemic cause or to a focus of infection. A delayed union may be the result of syphilis, or an infectious arthritis may be superimposed on a traumatic one. Occasional bad results are caused by nutritional defects that might have been discovered and corrected. If an operation is needed to secure good alignment of bones or for any other purpose, and the time is sufficient, bad teeth and tonsils should be removed. This procedure would, of course, apply to any focus of infection. We should always keep in mind

*Read before the Tenth Annual Meeting of the American Association of Industrial Physicians and Surgeons in Atlantic City, May 25-26, 1925. Received for publication Aug. 17, 1925.

the danger of hiding an acutely swollen part in a cast.

In this brief presentation it must be taken for granted that proper reduction has been accomplished and retention apparatus applied. Nor is there time for discussing special treatments of fractures in certain locations.

Motion

In all cases some form of motion should be used as soon as it is safe to do so. The choice of this time is a difficult matter and must be determined by taking into account all discoverable factors. In some fractures, Colles' for example, early motion is desirable if stiffness is to be avoided. Experience has shown that with fractures in some locations manipulative measures may safely or preferably be delayed. The length of time that joints may be immobilized without undue risk of stiffness or ankylosis varies with different joints, so that when a fracture involves a joint, judgment is severely taxed to determine just when motion should be begun.

Heat, Massage, and Electricity

Before Removal of Splints

In fractures not involving joints, it has long been recognized that something should be done before the splints may safely be discarded. Oven heating, massage, and passive motion are being used with increasing frequency. Complete repair and restoration of function are greatly hastened by really skilful massage, the splints being removed for this purpose and immediately reapplied. The value of this massage has been corroborated by X-ray proofs; its usefulness, however, is impaired by the difficulty of securing masseurs of requisite skill.

The less cumbersome types of splints devised during the late war often make possible adequate treatments without their removal. Dr. A. E. Barclay strongly advocates using the sinusoidal current applied through appropriate openings in the splints. With a small amount of current the stimulation needed for keeping muscles and skin in good condition may thus be given without violating the principle of rest for the broken parts. It is often easy to give useful treatments without removing the splints if access may be had to the limb above and below the splints. Or with a little care, splints may be so fenestrated that this is possible without lessening the efficacy of the splint.

The measures of distinct value that may be used in this way are: (*a*) diathermy; (*b*) surging currents—of faradic type when there is no nerve involvement; the sinusoidal or surging galvanism if there is sufficient nerve injury to give any evidences of reaction of degeneration. Should there be any sensory disturbance, diathermy is unsafe except in the hands of a well-experienced operator, as the risk of a severe burn is too great.

The best type of active hyperemia follows the use of diathermy with comparatively small amperages and prolonged applications; *e.g.*, in treating an arm, give 400 or 500 milliamperes for thirty minutes through electrodes larger than the cross section of the arm. The result is a localized non-infectious fever which gives the widest scope to the reparative powers of the blood, raises the efficiency of metabolism, relieves pain, and assists in

maintaining the muscles in good condition. Being an active and not a passive hyperemia, any tendencies toward pathologic deposits or bacterial invasion are combated. That this hyperemia is of considerable duration seems proved by the prolonged relief afforded patients who suffer from subjective sensations of coldness. I believe this treatment would be of great advantage in preventing or limiting the unfortunate atrophic changes that sometimes occur in joints distal to the fracture and cause such severe and permanent crippling.

Both mechanical obstacles and difficulties of collaboration between the surgeon and the physician familiar with physical methods of treatment will delay any extensive use of these measures before the removal of the splints. But they should be started as soon as retention apparatus may safely be discarded.

At all stages, except possibly during the first three or four days, diathermy will prove valuable. Its stimulation of reparative processes has been mentioned. Another most beneficial effect is its promotion of vascularization in scar tissue, so that the scar is softer, better nourished, more easily stretched should this be necessary for the restoration of full function, and less likely to cause nerve pressure by retraction. Following compound fractures the surgical removal of masses of scar tissue must at times be attempted in order to relieve nerve pressure. Two to four weeks of diathermy preceding such an operation so softens the scar that the procedure is much easier, causes less traumatism, and gives the best chance for restoration of nerve function.

Passive motions or motions produced by some electrical applications, or both, are used in graduated doses as the indications warrant. The use of any form of manipulation or motion invariably should be preceded by a thorough application of heat. When a part is thoroughly warm, much more may be accomplished in moving it, and with less discomfort to the patient.

From any source heat will be of value. We may use the whirlpool bath, radiant light and heat, infra-red heat, oven heating, or diathermy. Of these, diathermy is superior in the average case, because the heat is developed within the tissues with certainty that it goes just where we wish to have it applied and that its action is prolonged beyond the actual time of application. Other sources of heat are external; their effects are most marked on or near the surface, their penetrability is less as well as less accurately determined, and their reflex effects have to be taken into account, for the deeper effects are partly reflex.

After Removal of Splints

After the splints are discontinued the static wave current is a most valuable application for removing the muscular stiffness and getting rid of induration. The treatment may be so controlled that any desired amount of motion may be produced. Patients as a rule will tolerate more motion from this source than from any other. It is especially indicated if there is any tendency toward ankylosis, the electrodes being applied about the joint with little resultant muscular response.

SUMMARY

1. Have a thorough X-ray study. Secure best position of broken bones, and check with X-ray.

2. Eliminate all possible sources of infection.

3. Induce earliest motion possible with safety.

4. Use heat, massage, and electricity to maintain good nutritive condition, often preferably before splints are discontinued.

5. Correct errors in metabolism.

6. Use diathermy preceding scar excision.

7. Use surging currents, static wave, and heat after splints are discontinued.

THE THERMAL INDEX OF ATMOSPHERIC CONDITIONS AND ITS APPLICATION TO SEDENTARY AND TO INDUSTRIAL LIFE*

C. P. YAGLOU

Instructor in Ventilation and Illumination, Harvard School of Public Health, Boston, Mass.; Formerly Research Engineer, American Society of Heating and Ventilating Engineers' Research Laboratories, Pittsburgh, Pa.

INTRODUCTION

OUR conception of the causes of bad ventilation has changed in the last twenty years, through the substitution of research work for guesswork. The "crowd poison" theory is no longer tenable, and authorities agree that the most important principle in general ventilation is the maintenance of thermic conditions in the air which will promote normal heat loss from the body.

With the acceptance of this principle, speculation centers on the question as to which of the three physical air factors constitutes the most accurate index of human comfort. Heberden (1), one of the earliest students of this problem, realized the inadequacy of judging comfort from the indications of any single instrument, such as the dry or the wet bulb thermometer. Haldane (2) (3) (4) concluded that the wet bulb temperature alone was the correct index, without regard to dry bulb temperature, humidity, or dew point temperature. Bruce (5), on the other hand, concluded in 1916 that any attempt to judge atmospheric conditions by means of the wet bulb alone was misleading and that the dew point rather than the wet bulb temperature gave the truest index.

These speculations led the Research Laboratory of the American Society of Heating and Ventilating Engineers, in co-operation with the United States Bureau of Mines and the United States Public Health Service, to undertake an extensive study of the problem. The investigation is still in progress, but the evidence already accumulated shows that all three factors—*viz.*, dry bulb temperature, wet bulb temperature, and air movement—affect the human body in accordance with certain thermal laws, which have been incorporated into the effective temperature scale.

Some of the results of these experiments are briefly discussed in this paper, and are supplemented by a section on the practical application of effective temperature to sedentary and to industrial life.

THERMOMETRY OF ATMOSPHERIC CONDITIONS

The Thermodynamic Functions of the Body

In its thermodynamic functions, the human body resembles a combined

* Received for publication July 25, 1925.

unit of boiler and engine. The heat resulting from oxidation within maintains the body at a temperature well above that of the surrrounding air. This temperature is normally constant, because the loss of heat from the surface equals the rate at which heat is produced. If the heat loss is retarded, the temperature of the body rises, producing feelings of discomfort and depression, and finally proving serious or even fatal.

Normally the body loses heat by radiation, convection, and evaporation. Heat loss by radiation depends on the difference in temperature between the body and the surrounding objects. Heat loss by convection depends not only on this difference in temperature, but also on air movement. Air motion carries away the heated air in contact with the body and evaporates moisture from the skin and lungs at a rate depending on the wet bulb depression of the air (arithmetic difference between dry and wet bulb temperatures) and the velocity of air movement.

It follows, therefore, that the thermal condition of the atmosphere is the determining factor in heat loss, and is therefore of great importance to human comfort. Within certain limits of temperature, heat production and loss are accurately balanced, either by means of chemical regulation which stimulates metabolic activity at low temperatures, or through physical regulation which increases heat loss by perspiration.

Equivalent Conditions of Temperature, Humidity, and Air Movement

For a given degree of warmth or comfort, temperature, humidity, and air movement may vary considerably, so long as their combined effect remains the same. Different combinations of the three factors which produce the same feeling of warmth give what are called equivalent conditions.

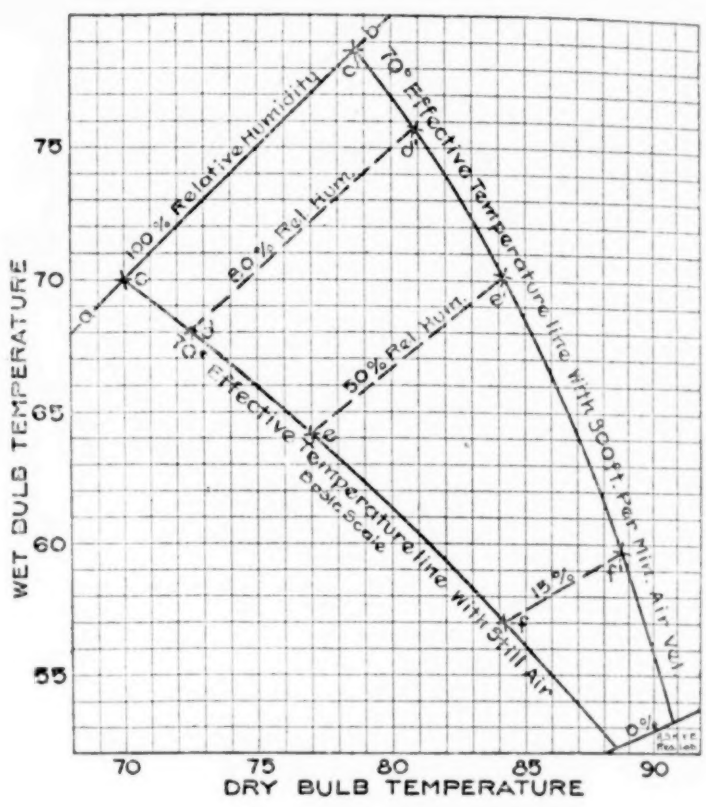

FIG. 1.—Chart showing equivalent condition of temperature, humidity, and air movement in still air and in air which is moving with a velocity of 300 feet a minute.

The curved lines in Figure 1[1] show equivalent conditions of 70° in still air and in air which is moving with a velocity of 300 feet a minute, as they were determined in the psychrometric chambers of the Research Laboratory at Pittsburgh (6) (7) by three subjects at rest, stripped to the waist. One of the chambers was maintained at a saturated condition of 70°, represented in the figure by point c. The wet bulb temperature in the second chamber was kept lower than that in the first, and when the feeling of warmth of the two rooms was

[1] All figures by courtesy of the American Society of Heating and Ventilating Engineers.

compared, it was found that the dry bulb temperature of the second room had to be increased successively to the values represented by points d, e, and f, for the warmth of the two chambers to remain the same.

In experiments with air movement, the conditions represented by points c, d, e, and f were produced in one chamber in still air, while a uniform air velocity of 300 feet a minute was set up in the other. It was then found that, with the same relative humidity in both chambers, the dry bulb temperature of the second chamber had to be increased to the values shown by c′, d′, e′, and f′ to counterbalance the cooling effect of wind. Line c′ f′ was thus found to be the 70° line of equivalent conditions when the air velocity was 300 feet a minute.

The complete results of the investigation, covering a range of 28° to 170°F. dry bulb and 25° to 115°F. wet bulb, for human beings at rest, both stripped to the waist and normally clothed, have appeared elsewhere (8) (9).

Thermometric Charts

As will be shown later, this newly developed scale of equivalent conditions not only indicates the warmth felt by the body, but also determines the physiologic effects produced on it by heat: hence the effective temperature scale.

"An atmospheric condition has an effective temperature of 65°F. when it is equivalent to a saturated one of 65°F. in still air." Thus far two such scales have been drawn up, the basic and the normal. In the first, the subjects were stripped to the waist, so that the problem could be studied under conditions of maximum sensitivity to external temperature. The normal scale of effective temperature was determined with subjects wearing customary clothing.

The thermometric charts in Figures 2 and 3 are self-explanatory. They present the thermal laws of the body in a simple and practical form, in terms of effective temperature.

The Comfort Zone

The comfort zone (10) is shown in Figure 3 by the dotted area. It was determined by the consensus of opinion of 130 subjects of both sexes, engaged in widely different occupations and wearing various types of indoor clothing. Conditions of maximum comfort are represented by the 66° effective temperature line, the preference of 98 per cent. of the subjects, regardless of the temperature or the humidity of the air.

Physiologic Importance of the Effective Temperature Index

In the experiments described above, we did not determine the lines showing equivalent conditions from any physiologic data other than the sensation of warmth or cold perceived through the sense areas in the skin. Subsequently, however, we investigated other physiologic reactions of men to various high temperature conditions (11) (12) (13) (14), exposing them in the psychrometric rooms for as long a period as they could endure, sometimes as long as three hours at a time. Before, during, and after exposure, their rectal, mouth, and skin temperatures, pulse rate, systolic and diastolic blood pressures, body weight,

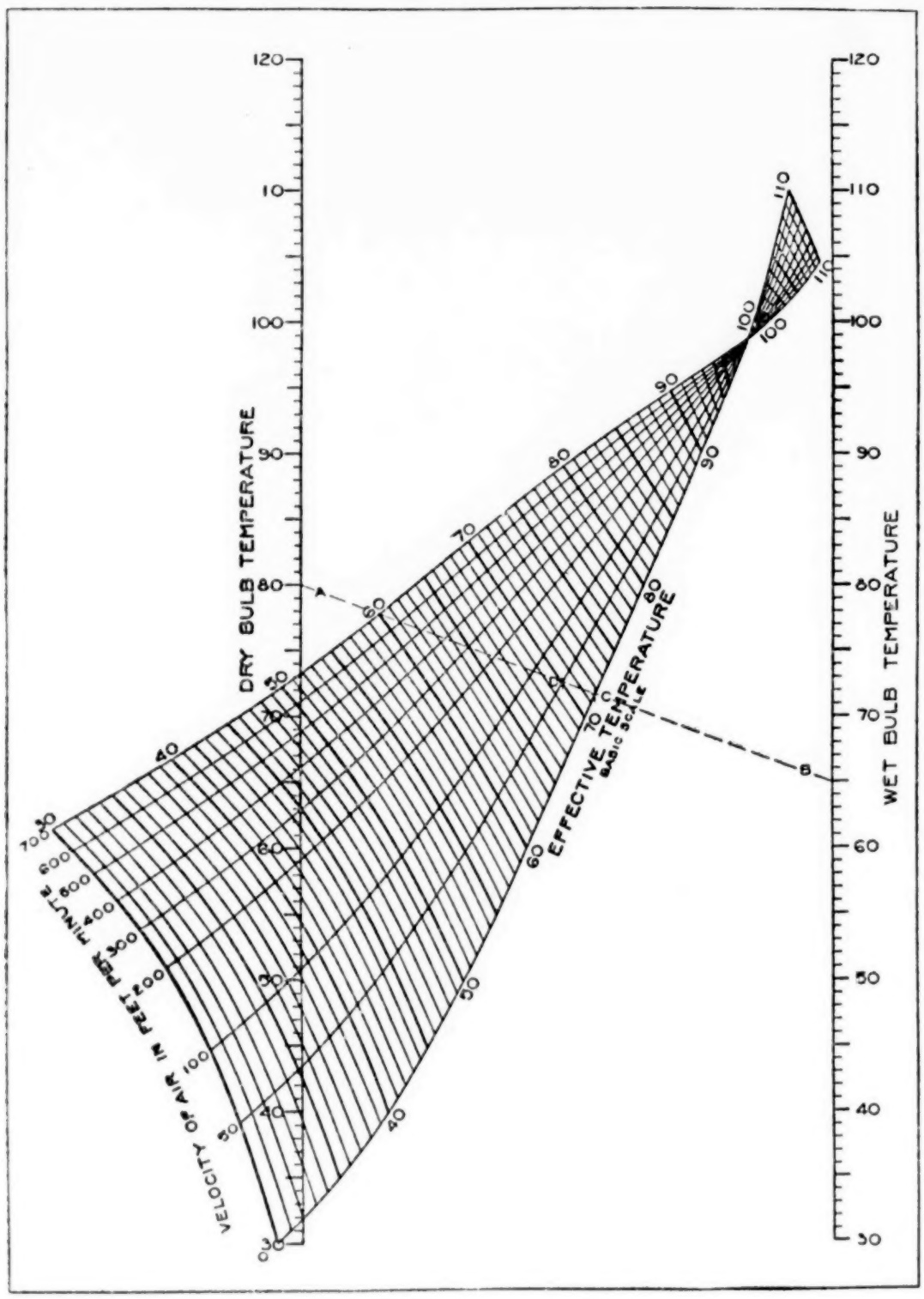

FIG. 2.—Thermometric chart showing basic scale of effective temperature.

Example in Use of Chart

Given dry bulb 80°, wet bulb 65°, velocity of air 50 feet per minute.

1. Draw line AB. Its intersection with the 50-foot velocity curve at D gives 70° for the effective temperature of the condition.
2. Follow line AB to C and read 71.6° for the effective temperature with still air.
3. The cooling produced by the movement of the air is:

$$71.6° - 70° = 1.6°$$ effective temperature.

and samples of expired air were taken in order to calculate basal metabolism.

After determining the effective temperature scale from sense reactions alone, it was gratifying to find that the physiologic reactions followed this new index as closely as could be expected, regardless of dry bulb or wet bulb temperature, dew point temperature, relative humidity, or air motion.

Table 1 shows the close agreement

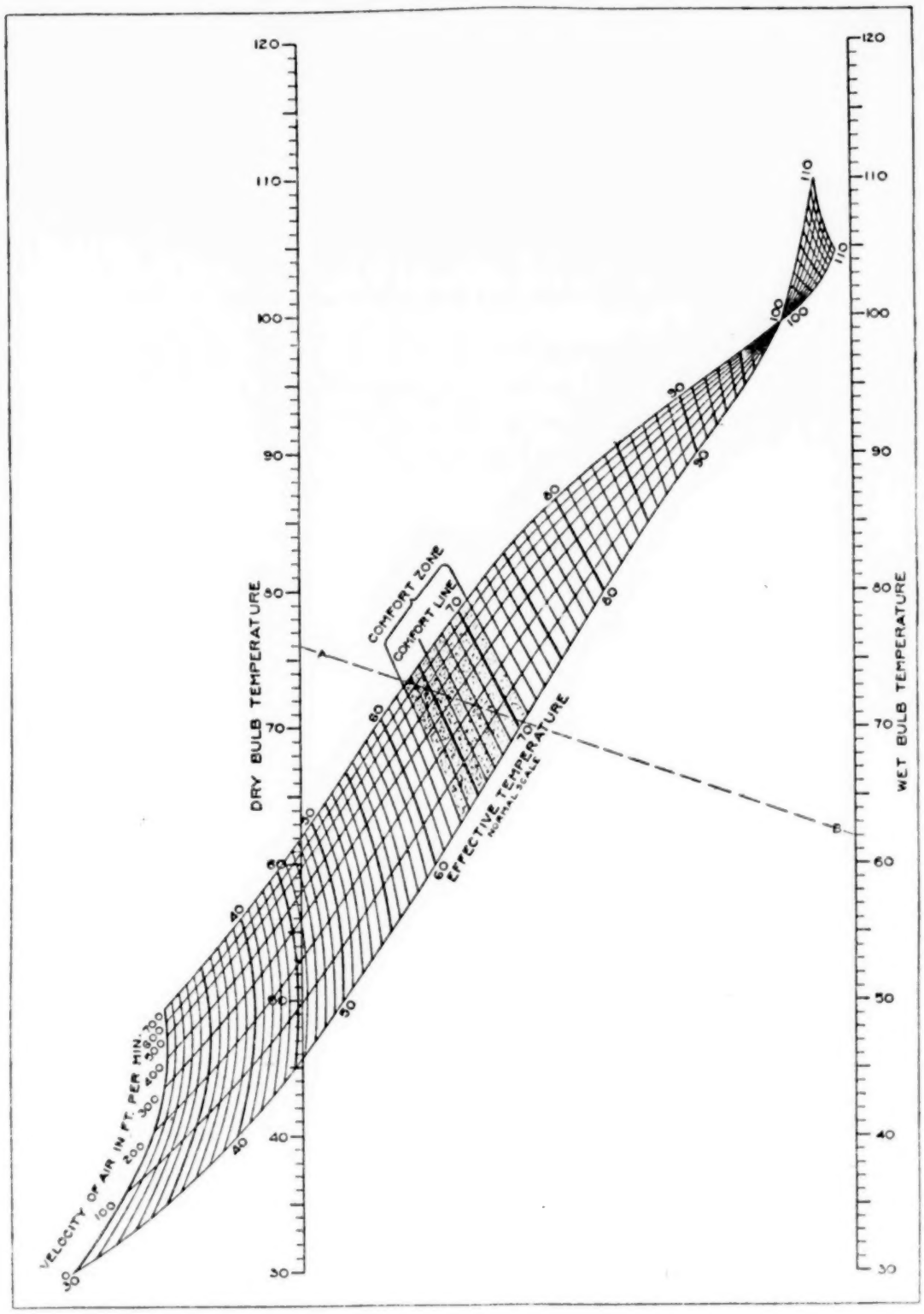

FIG. 3.—Thermometric chart showing normal scale of effective temperature.

Example in Use of Chart

Given dry bulb 76°, wet bulb 62°, velocity of air 100 feet per minute, determine: (1) effective temperature of the condition; (2) effective temperature with still air; (3) cooling produced by the movement of the air; (4) velocity necessary to reduce the condition to 66° effective temperature.

1. Draw line AB through given dry and wet bulb temperatures. Its intersection with the 100-foot velocity curve gives 69° for the effective temperature of the condition.

2. Follow line AB to the right to its intersection with the 0 velocity line, and read 70.4° for the effective temperature with still air.

3. The cooling produced by the movement of the air is 70.4° − 69° = 1.4° effective temperature.

4. Follow line AB to the left until it crosses the 66° effective temperature line. Interpolate velocity value of 340 feet per minute, to which the movement of the air must be increased for maximum comfort.

between the effective temperature of the air and the corresponding rate of increase in the physiologic reactions represents the average data for several subjects at rest, stripped to the waist.

TABLE 1.—SHOWING AGREEMENT BETWEEN EFFECTIVE TEMPERATURE AND PHYSIOLOGIC REACTIONS, AND ALSO EXTENT OF DISAGREEMENT OF PHYSIOLOGIC REACTIONS WITH ANY OTHER SINGLE AIR FACTOR

TEST NO.	TEST CONDITIONS					RATE OF CHANGE IN PHYSIOLOGIC REACTIONS		
	Effective Temperature	Dry Bulb Temperature	Wet Bulb Temperature	Relative Humidity	Dew Point Temperature	Rise in Rectal Temperature	Increase in Pulse Rate	Loss in Body Weight
	°F.	*°F.*	*°F.*	*%*	*°F.*	*°F./hr.*	*beats per min./hr.*	*lbs./hr.*
56	106.0	106.0	106.0	100.0	106.0	4.27	104.9	2.78
72	106.2	120.0	104.6	60.0	102.2	4.70	127.8	2.58
80	106.4	157.0	100.4	15.0	89.1	4.60	124.2	3.19
53	101.3	102.1	101.2	99.2	101.1	2.53	56.3	1.90
76	101.8	129.3	97.5	30.2	91.1	2.45	51.6	1.57
78	101.1	130.0	96.4	30.0	89.4	2.44	54.3	2.05
79	101.2	146.0	93.6	15.0	80.1	1.90	42.5	1.67
44	95.1	97.1	94.6	91.2	94.1	0.85	14.4	0.93
58	94.9	106.0	92.2	60.0	89.0	0.72	10.3	0.93
74	95.2	120.0	89.2	30.0	81.0	0.87	14.0	0.86
81	95.1	144.7	81.8	5.0	54.0	0.75	12.8	1.03
83	85.0	85.0	85.0	100.0	85.0	0.06	1.0	0.07
45	89.3	99.0	86.2	60.0	82.8	0.32	6.6	0.50
71	92.8	116.0	86.2	30.0	77.3	0.52	7.3	0.64
81	95.1	144.7	81.8	5.0	54.0	0.75	12.8	1.03

produced on three subjects at rest, stripped to the waist. It will be observed that, with constant effective temperature, the physiologic reactions are practically constant, while the dry and wet bulb temperatures, the relative humidity, and the dew point temperature vary considerably. As the effective temperature increases, the reactions correspondingly increase.

Some correlations of effective temperature with the rate of change in physiologic reactions are shown in Figures 4 to 9, where each point

Figure 8 shows the basal metabolic rate of several subjects at different effective temperatures. This correlation is not so useful as the previous ones, because the points represent actual heat production, regardless of the period of exposure, and not the rate of increase in heat production. The information is valuable, however, since it shows that the metabolic rate does increase with exposure to high temperatures, as well as with exposure to temperatures below normal, as the result of changes in body temperature

and pulse rate. It shows, moreover, that it is not necessary to place a man in a neutral bath with a temperature of 97°F. in order to measure the mini-

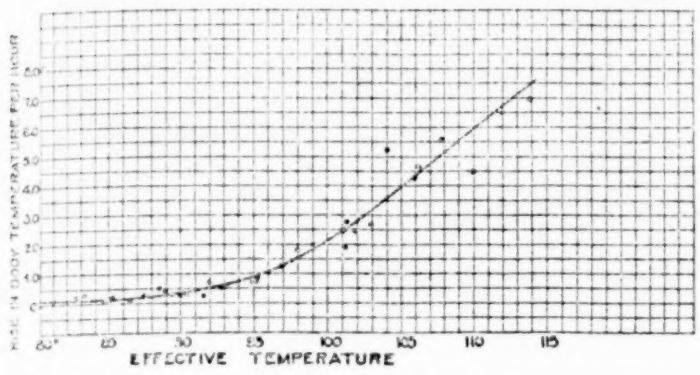

FIG. 4.—Correlation of effective temperature with the rate of increase in rectal temperature—°F. per hour.

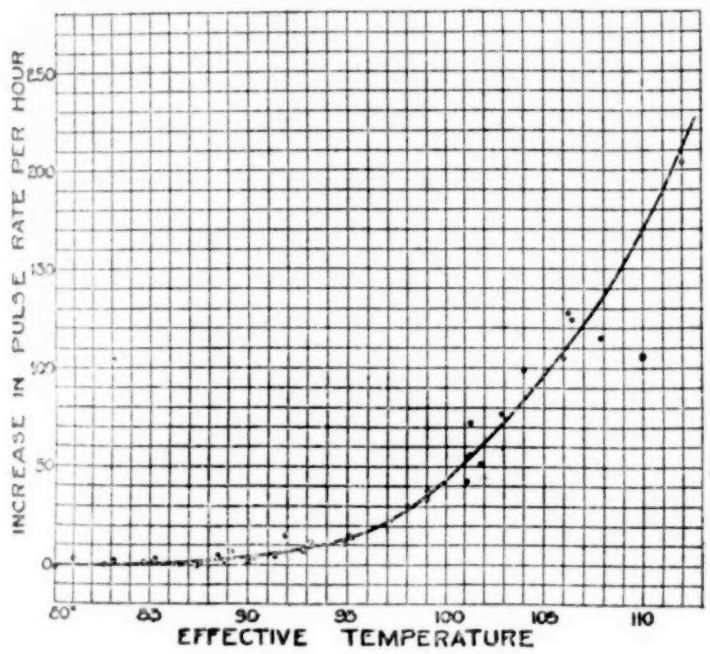

FIG. 5.—Correlation of effective temperature with the increase in pulse rate—beats per minute per hour.

mum basal metabolic rate.[2] The same thing can be accomplished in air with an effective temperature between 75° and 83°, when the upper part of the body is uncovered. If the subject is fully clothed, the optimum condition will, of course, occur at a lower effective temperature.

Further work of a more detailed nature on basal metabolism is now in progress in this Laboratory.

[2] This conclusion is in agreement with the recent findings of the Benedicts (15).

GENERAL DISCUSSION

Modification of Haldane's Wet Bulb Theory

From Figures 2 and 3, it can be seen that at low temperatures dry bulb temperature is a more important index

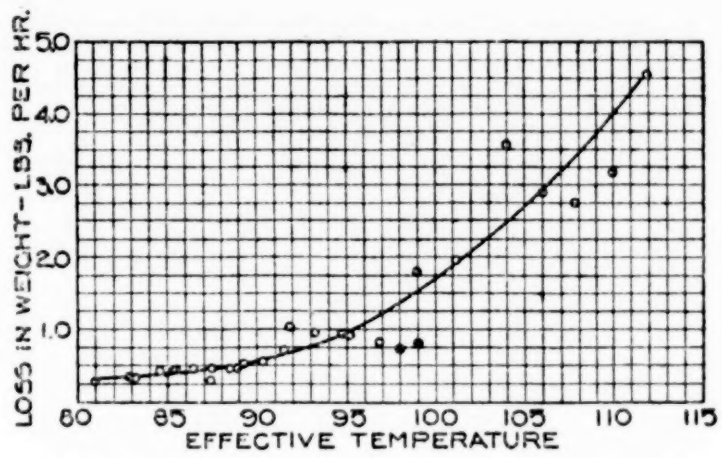

FIG. 6.—Correlation of effective temperature with loss in body weight—pounds per hour.

than wet bulb, because the body surfaces are dry and so approach the condition of a dry bulb thermometer. Conversely, at high temperatures, where sensible perspiration comes into play, the reverse is true and wet bulb temperature is a more accurate index.

Undoubtedly it was this latter fact that prompted Haldane to conclude that the limit of endurance for resting men stripped to the waist was in the neighborhood of 88°F. wet bulb, regardless of any other physical air factor. It is true that the limit of endurance under these conditions is not far from 88° wet bulb when the air is saturated with moisture. For dry bulb temperatures higher than 88°, the wet bulb must be correspondingly reduced; otherwise, the body will lose its temperature equilibrium and physiologic reactions will keep on increasing at an accelerated rate, depending on the effective temperature of the air. For instance, with the same wet bulb tem-

perature of 88° but a dry bulb of 140°, it can be seen from Figures 2, 5, and 6 that the body temperature will rise at the rate of 1.4°F. an hour and the

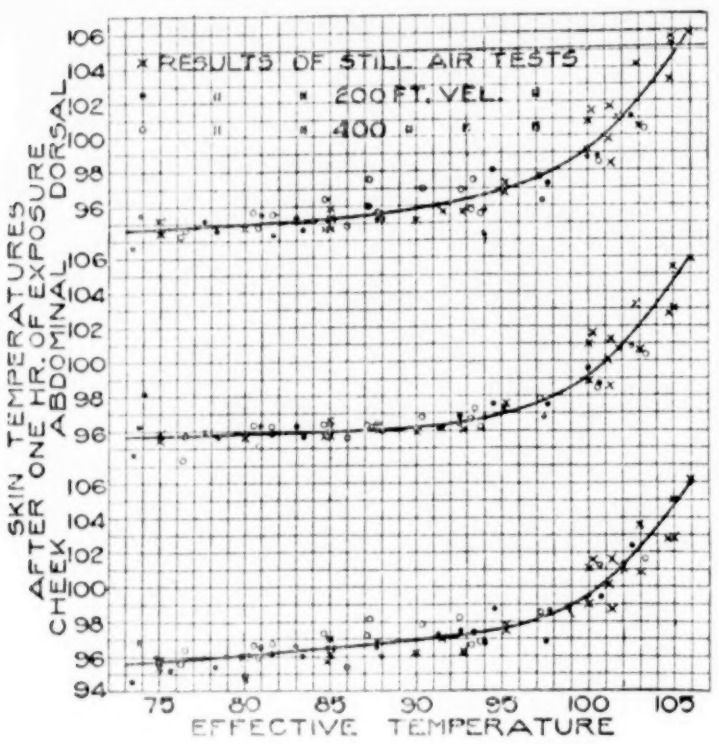

FIG. 7.—Correlation of surface temperature with effective temperature.

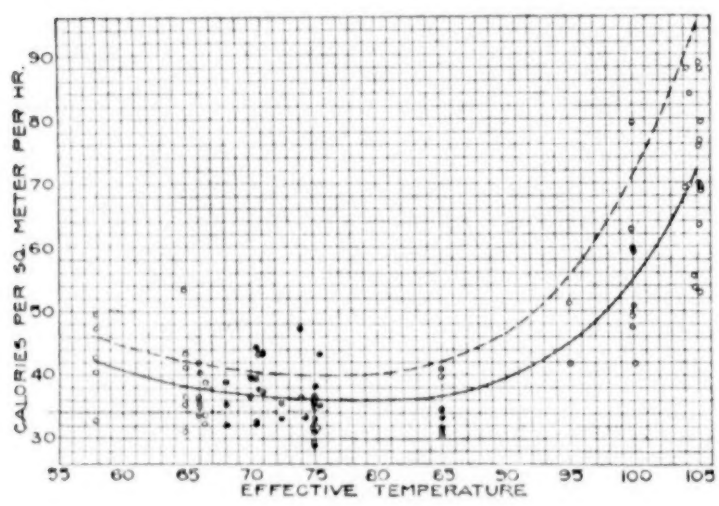

FIG. 8.—Correlation of effective temperature with metabolic rate. Solid curve represents the basal metabolic rate. Dotted line shows the effect of regular meals and sitting position.

pulse rate will increase at the rate of 25 beats a minute each hour, because the effective temperature is no longer 88° but 97.5°. Haldane's statement, therefore, should be modified by substituting the words effective temperature for wet bulb temperature.

The Kata-Thermometer as an Index of Comfort

Although there are several instruments on the market which, it is claimed, will measure the comfort of atmospheric conditions, it is very questionable whether any single instrument can be designed which will answer the purpose. Perhaps the best device of the kind is Hill's kata-thermometer, which is extensively used in England. Its value and defects have been discussed elsewhere (16), and it will suffice here to show its inconsistency by comparing a few equivalent kata conditions with the comfort zone in Figure 3. According to Hill, a dry kata cooling power of 6 millicalories per square centimeter per second is an index of good ventilation and produces comfortable conditions for sedentary occupations. This cooling power corresponds to:

Dry Bulb Temperature °F.	*Air Velocity* ft. per min.
57.7	still air
70.8	50
75.5	100
85.6	500

Referring now to Figure 3, it will be seen that, regardless of humidity, a still-air condition of 57.7°F. is entirely too cold for comfort; one of 85.6°F. with an air velocity of 500 feet a minute, on the other hand, is too warm. Assuming a normal humidity of 50 per cent., the wet bulb temperature is 48.5° when the dry bulb is 57.7°, and 71.5° when the dry bulb is 85.6°. These two combinations correspond to about 56° and 74° effective temperature respectively, and both of them lie outside the comfort zone. Of the four equivalent kata conditions,

only the second is comfortable, since, with normal humidity, it corresponds to an effective temperature of 66°.

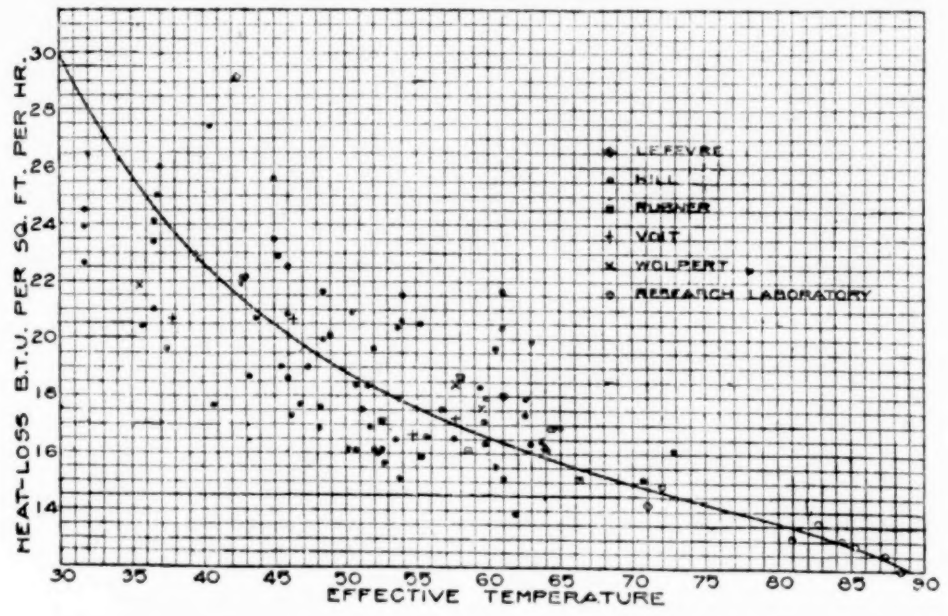

FIG. 9.—Correlation of effective temperature with the rate of heat loss from the surface of the body, under ordinary, resting condition, according to different investigators (17).

Although the kata-thermometer does not entirely answer the purpose for which it is designed, it is valuable as an anemometer because it adds unidirectional air currents and eddies which cannot be determined by a vane anemometer. Moreover, for air velocities below 200 feet a minute, the kata-thermometer is far superior to any vane anemometer.

The Effect of Drinking Water and the Effect of Ammonia in the Air

It has been stated lately (18) that water drunk freely during exposure to high temperatures is very helpful in maintaining the organism in a normal condition. Our experience fails to corroborate this statement, even in cases where iced water was drunk in large quantities.

We have observed, however, that perceptible quantities of ammonia in the air not only check the rise in body temperature but may even lower it. This was observed accidentally during experiments in the Pittsburgh laboratory, through leakage in the ammonia coils inside the psychrometric chambers. At other times, the writer and some of his associates had often noticed a faint smell of ammonia at very high temperatures, particularly when the air was saturated with moisture. It was always assumed that it might have been caused by leaks in the ammonia system, although after careful examination no such leaks could be detected. This experience, however, has recently been repeated in the psychrometric room of the Harvard School of Public Health, where there is no ammonia system. Sweat samples taken from different parts of the body after ten minutes' exposure to a saturated condition of 125°F. showed an ammonia content of from 3.5 to 5 mg. per 100 c.c. The writer was unable to find in the literature figures for the normal ammonia concentration in sweat. Further experiments of the kind are in progress in this Laboratory.

The Practical Application of Effective Temperature

With the increased complexity of life during the past twenty years, the need for ventilation and for artificial cooling in theaters, schoolrooms, auditoriums, and the like, especially in warm weather, has correspondingly increased. The evils of excessive atmospheric heat are well known to industrial workers, and adequate ventilation in many of our industrial establishments is a matter of great importance to the public health.

The use of air movement is the simplest and the most inexpensive method of cooling. At very high temperatures, however, as shown in the thermometric charts in Figures 2 and 3, the benefit derived from air movement is small, and the effective temperature must be lowered by other means before the air is set in motion.

The evaporation of water, one of the oldest and most important principles of air conditioning, can be applied for lowering the effective temperature of the air. When unsaturated air is brought into direct contact with water —when, for instance, it is passed through a humidifier or air washer— a certain amount of heat is abstracted from the air, effecting an appreciable lowering in its temperature. Unless heat is added to or subtracted from the system, the wet bulb temperature of the air remains the same and the dry bulb increases until it becomes identical with the wet bulb. when the saturation point is reached. When this saturated air is set in motion, its cooling power is very great.

This method of artificial cooling is especially adapted to use in industrial plants where temperatures are high and the humidity is low. It requires simple and inexpensive equipment, such as humidifiers and blowers, the cost of which are very much less than the cost of the equipment used for refrigeration.

In Sedentary Occupations

The thermometric chart in Figure 3 is applicable to ordinary conditions where normal clothing is worn and where physical activity is slight. The comfort zone and the comfort line represent conditions that should be maintained in dwellings, office buildings, theaters, schools, and other places of the kind, where mental or light physical activities are carried on. In summer, when thinner clothing is worn, the comfort line will approach the lower limit of the comfort zone; with the heavier clothing worn in winter, it will approach the higher limit.

Although all the equivalent conditions represented by the comfort line are equally effective, practical considerations limit the range of humidity from 30 per cent. to 70 per cent. This reduces the limits of the dry and wet bulb temperatures in still air from 68° dry and 62° wet bulb to 72° dry and 54° wet bulb, each difference of 1° dry bulb on the chart being equivalent to 2° wet bulb.

The cooling of such buildings as are mentioned above can be accomplished by the evaporation of water and by slight increase in air movement. It is not advisable in such places to increase the air movement beyond 100 feet a minute.

In Hot Industries

Adverse conditions of temperature and humidity in many industries impair the health and the vitality of the workers and lower the quality and the quantity of the output. The problem is a serious one both for the manufacturer and for the worker.

In a report on the importance of temperature and humidity in places where physical labor is being carried on the New York State Commission on Ventilation (19) states that men perform 28 per cent. less physical work in a temperature of 86°F. with 80 per cent. relative humidity than they do in a temperature of 68°F. with 50 per cent. relative humidity.

Our recent experiments at the Pittsburgh laboratory (20), carried out in temperatures that are frequently found in certain industries, showed that the subjects were capable of performing about five times as much work in a temperature of 90° with a relative humidity of 30 per cent. as they were in a saturated condition at body temperature. With a normal humidity of 60 per cent., the subjects accomplished two and one-half times as much work in ordinary temperatures as they did in a temperature of 110°.

The same experiments show also that the highest temperature which can be maintained for muscular work to proceed without loss of efficiency is about 80° effective temperature. With an effective temperature higher than 85°, the body loses its heat equilibrium and physiologic reactions continue to increase with length of exposure. These temperatures are higher than the optimum for men at rest, because the workers in hot industries are very lightly clad and become acclimatized to higher temperatures. Adequate ventilation in hot industries, therefore, should prevent the effective temperature from exceeding 80° and should, at the same time, dispose of the injurious dusts and fumes incidental to the processes of manufacture.

In Steel Mills

The conditions which workers encounter in the steel industry are especially trying. Here men are often exposed to temperatures as high as 220° in the vicinity of the furnaces and plates, so that after short periods of work they must stop to rest and cool off while a new shift takes their place.

It has been shown how high temperature conditions in general can be improved by means of saturation and air movement. Let us consider an actual application of that method in a steel mill near Pittsburgh. The average conditions in this mill in summer were about 112° dry bulb and 86° wet bulb, with an air movement of 100 feet a minute created by the natural circulation of air. A marked drop in output was observed during the summer months and various methods were considered for remedying the condition.

From Figure 2 we find that the effective temperature in the workrooms was 91°, or 11° above the proper limit. By simply saturating the air at the wet bulb temperature of 86° and blowing it upon the workers with a velocity of 400 feet a minute, the effective temperature may be theoretically lowered to 80°. In practice, these theoretical values will have to be

modified according to the clothing worn, the type of work performed, and the diffusion of the air before it strikes the bodies of the workers. In any case, however, the desired improvement can be obtained by further increasing the velocity of the air.

This elementary method of artificial cooling can be satisfactorily applied in small industries by the use of small humidifiers which will saturate the air locally and blow it directly upon the heads of the workers. In large industrial establishments, it is more efficient to saturate the air in a central humidifier and then blow it through overhead ducts upon the workers. In such cases, outside air can be drawn in through the humidifier, and, since its wet bulb is lower than that of the air in the workrooms, a greater cooling effect can be obtained. With outside air of 95° dry bulb and 80° wet bulb, the effective temperature of the air striking the workers can be reduced to 74° with an air velocity of only 200 feet a minute. This method of aritficial cooling not only lowers the temperature in the place of work; it also provides a supply of fresh air and removes the products of respiration and the dusts and fumes created in the process of manufacture. Moreover, saturation gives moisture to the relatively dry air and eliminates the burning effect of the hot air and its harmful influence on the respiratory organs.

In Mines

The principal objects of mine ventilation are the reduction of the temperature at the working places underground and the provision of fresh air to dilute and remove noxious fumes, dusts, and inflammable gases resulting from the use of explosives.

The atmospheric conditions in a deep mine depend largely on the depth of the mine, the rock temperature, and the presence of water in the shafts and drifts available for evaporation. It can be shown that these conditions are far from satisfactory by referring to the findings of Orenstein and Ireland (21) who estimated the working efficiency of miners in the Rand by means of a dynamometer and ergometer. The figures given below are based on dry kata-thermometer cooling power, with the assumption that the working efficiency is 100 per cent. at a dry kata power of 6 millicalories per square centimeter per second.

Dry Kata Cooling Power	*Working Efficiency*
millical./sq. cm./sec.	%
1	50
2	60
3	70
4	80
5	90
6	100

It will be observed that working efficiency decreased when the kata power fell below 6, until at 1 millicalorie per square centimeter per second the average efficiency was only 50 per cent., while the body temperature rose considerably and extreme fatigue resulted.

Many similar cases are given by Sayers and Harrington, Haldane, and others, where the temperature conditions were such that the miners could remain at work only a part of the time, spending the greater part in resting and cooling off. The importance of cooling the air either by saturation

or by air movement has been brought out in the experiments of these investigators. It was also found that air conditions corresponding to an effective temperature of 80° constitute the highest limit which is satisfactory for men working underground.

The economic aspects of the use of this method of cooling in mines are demonstrated in the Morro Velho Mine (22) where a cooling plant was installed. The average condition underground prior to March, 1920, was 101.5° dry bulb and 87° wet bulb, with a wet kata cooling power of 7.7 millicalories per square centimeter per second. In April, 1922, an expensive refrigerating equipment was installed at the surface, with a capacity of 100,000 B.T.U. a minute, with an additional Sirocco blower of 200 horse power to effect a total air supply of 60,000 cubic feet a minute. By means of these, the dry bulb temperature was reduced from 101.5° to 97.4°, the wet bulb from 87° to 76.2°, and the wet kata cooling power was increased from 7.7 to 20.5 millicalories per square centimeter per second.

Assuming that the wet kata-thermometer can be depended on for velocity determinations, the computed values are 220 feet a minute prior to March, 1920, and 540 feet after the changes were made. The original condition (101.5° dry bulb, 87° wet bulb, and 220 feet a minute) corresponds to an effective temperature of 88°, and was reduced by refrigeration and increased air movement to 78.7°, with a resulting improvement of 88°—78.7° = 9.3° effective temperature. Of this total improvement, 7.4° is apparently due to refrigeration alone, and 1.9°, or 20 per cent., is due to the increased velocity of the air.

It is of economic significance to discover that the same improvement can be obtained theoretically by saturation and increased air movement, without the use of refrigerating equipment. By simply saturating the air, both dry bulb and effective temperatures are reduced to 87°, while a velocity of 560 feet a minute will further reduce the effective temperature to 78.7°, a total improvement equal to that obtained by the combination of refrigeration and air movement.

An estimate of the initial cost and of the cost of operating the refrigerating equipment, as compared with the corresponding costs of a simple humidifier, will disclose the enormous saving in investment and power consumption accomplished by this method.

The low efficiency of refrigeration in mine ventilation is due to the fact that, when the incoming air is cooled, the difference in temperature between the rock of the shaft and the air is increased and the air absorbs more heat from the rock than it did formerly. The result is that the air reaches the bottom only a few degrees cooler than it was before the cooling apparatus was installed. In the Morro Velho Mine, without cooling the air entered at the surface with a temperature of 76° and reached the bottom with a temperature of 101°; the cooled air entered at 42° and reached the bottom at 97.4°, a difference of only 3.6° as a result of cooling the air at the surface. If, on the other hand, the refrigerating equipment is installed underground,

difficulty arises in pumping the water used to remove the heat up to the surface of the mine.

Summary

1. The thermal index of atmospheric conditions was developed by comparing the warmth sensed under a wide range of temperature, humidity, and movement of the air. This was called effective temperature index. It can be determined by means of charts from the dry and wet bulb temperatures and the movement of the air.

2. Measurable physiologic effects of atmospheric conditions were found to follow closely the scale of effective temperature, regardless of temperature, humidity, and movement of the air.

3. The comfort zone at rest has been determined. It includes conditions between 63° and 71° effective temperature.

4. The practical application of effective temperature to sedentary and to industrial life is treated in detail. The upper limit of temperature efficiently endured with muscular work was found to be 80° effective temperature.

5. A method for improving hot industrial conditions is suggested, and is illustrated with numerical examples in representative industries.

BIBLIOGRAPHY

1. Heberden, W.: An Account of the Heat of July 1825; together with Some Remarks upon Sensible Cold. Phil. Tr. Roy. Soc. London for 1826, Part 2, p. 69.
2. Haldane, J. S.: Report to Secretary of State for the Home Department on the Health of Cornish Miners. H. M. Stationery Office, London, 1904, p. 93. Cited by H. M. Vernon: The Kata-Thermometer in Studies of Body Heat and Efficiency. Part V. The Index of Comfort at High Atmospheric Temperatures. Med. Res. Council, Special Rep. Series No. 73, p. 116. London, H. M. Stationery Office, 1923.
3. Haldane, J. S.: The Influence of High Air Temperatures, No. 1. Jour. Hyg., 1905, *5*, 494. Cited by Vernon: *Loc. cit.*
4. Haldane, J. S.: Work under Pressure and in Great Heat. Science Progress, 1907, N. S. *2*, 378. Cited by Vernon: *Loc. cit.*
5. Bruce, J. L.: Humidity and Temperature of Air in Relation to Comfort and Health. Read before Royal Society, N. S. W. (Public Health Section), Nov. 14, 1916. Cited by Vernon: *Loc. cit.*
6. Houghten, F. C., and Yagloglou, C. P.: Determining Equal Comfort Lines. Jour. Am. Soc. Heating and Ventil. Eng., 1923, *29*, 165.
7. Houghten, F. C., and Yagloglou, C. P.: Cooling Effect on Human Beings, Produced by Various Air Velocities. *Ibid.*, 1924, *30*, 169.
8. Yagloglou, C. P., and Miller, W. E.: Effective Temperature Applied to Industrial Ventilation Problems. *Ibid.*, 1924, *30*, 515.
9. Yagloglou, C. P., and Miller, W. E.: Effective Temperature with Clothing. *Ibid.*, 1925, *31*, 59.
10. Houghten, F. C., and Yagloglou, C. P.: Determination of the Comfort Zone with Further Verification of Effective Temperatures within this Zone. *Ibid.*, 1923, *29*, 515.
11. McConnell, W. J., and Houghten, F. C.: Some Physiological Reactions to High Temperatures and Humidities. *Ibid.*, 1923, *29*, 131.
12. McConnell, W. J., Houghten, F. C., and Yagloglou, C. P.: Air Motion, High Temperatures and Various Humidities—Reactions on Human Beings. *Ibid.*, 1924, *30*, 199.

13. McConnell, W. J., and Yagloglou, C. P.: Correlation of Skin Temperatures and Physiological Reactions. *Ibid.*, 1924, *30*, 457.

14. McConnell, W. J., Yagloglou, C. P., and Fulton, W. B.: Basal Metabolism before and after Exposure to High Temperatures and Various Humidities. *Ibid.*, 1925, *31*, 23.

15. Benedict, F. G., and Benedict, C. G.: The Neutral Bath and its Relation to Body Heat. Proc. Nat. Acad. Sciences, 1924, *10*, 495.

16. McConnell, W. J., and Yagloglou, C. P.: The Kata Thermometer: Its Value and Defects. U. S. Pub. Health Rep., 1924, *39*, 2293.

17. Yagloglou, C. P.: Heat Given Up by the Human Body and its Effect on Heating and Ventilating Problems. Jour. Am. Soc. Heating and Ventil. Eng., 1924, *30*, 597.

18. Flinn, F. B.: Some Effects of High Environmental Temperatures on the Organism. U. S. Pub. Health Rep., 1925, *40*, 868.

19. Report of the New York State Commission on Ventilation. New York, E. P. Dutton & Co., 1923.

20. McConnell, W. J., and Yagloglou, C. P.: Work Tests Conducted in Atmospheres of High Temperatures and Various Humidities in Still and Moving Air. Jour. Am. Soc. Heating and Ventil. Eng., 1925, *31*, 35.

21. Orenstein, A. J., and Ireland, H. J.: A Contribution to the Study of the Influence of Mine Atmospheric Conditions on Fatigue. Jour. So. African Inst. Eng., March, 1921, p. 126.

22. Davies, E.: The Air-Cooling Plant at the Morro Velho Mine of the St. John del Rey Mining Co., Ltd., Brazil. Tr. Inst. Mining Eng., London, 1921–1922, *63*, 326, 424.

THE TREATMENT OF INDUSTRIAL (SURGICAL) ACCIDENTS WITH A VIEW TO RESTORATION OF FUNCTION AND MINIMIZING SUBSEQUENT INCAPACITY: A PLAN FOR LARGE EMPLOYERS OF LABOR FOR DEALING WITH SUCH ACCIDENTS*

LEWIS E. HERTSLET, M.R.C.S. Eng., L.R.C.P. Lond.

Medical Officer to South African Railways & Harbours, and to Langlaagte Estate and Gold Mining Company, Ltd.
Florida, Transvaal

INTRODUCTION

THIS paper is written from the standpoint of South Africa, where a large proportion of industrial labor is performed by uncivilized natives. Certain factors, which follow, provide valid reasons for a careful study of the subject chosen for consideration.

Humanitarian Principles

It is highly desirable to use every possible means in order to lessen the physical pain of septic wounds and stiff joints, and to reduce the permanent weakness and disability which follow many accidents. Altruism demands a fuller recognition of the mental suffering due to blinded eyes, amputated limbs, enforced idleness, and the like, to say nothing of the bereavement of wife and children in accidents which are immediately or eventually fatal. Any measures that will diminish such suffering and tend to abolish such bereavement call for scientific inquiry and, when they are proved useful, for immediate adoption.

* Received for publication June 5, 1925.

International Legislation

The whole question of medical benefit after accidental injury forms a part of a questionnaire on workmen's compensation which has recently been sent to all the governments represented in the International Labour Conference—an important section of the League of Nations.

Replies to the following questions are invited from the governments concerned:

1. Should medical aid be a necessary part of compensation whether organized by the employer or by way of insurance institutions?
2. Should medical benefits include treatment by specialists? (Presumably this would include after-treatment by physiotherapy.)
3. Should compensation include the supply and renewal of artificial limbs—or should this be met by extra compensation in cash?
4. Should compensation in cases of death or serious incapacity be paid in the form of a pension, except where proper guaranties may be secured for the wise utilization of a lump sum?

The fact that these questions are being studied in other parts of the world provides a cogent argument for their consideration here.

Financial Loss

The fact must not be overlooked that very large sums are paid out annually by employers, insurance companies, and sick benefit societies as a direct, or indirect, result of accidents, avoidable or unavoidable. It is impossible to arrive at an inclusive total of the cost in South Africa for sick pay, medical fees, hospital charges, litigation, and compensation, but the figures as given in Tables 1, 2, and 3 represent a total of approximately £170,000, for one year, paid out to employees of the South African Railways & Harbours, to the European employees of seventy mines, and to native laborers on all mines, as the direct result of industrial injuries. A total of £250,000 would be a safe inside estimate for the whole country.

In a fatal accident, or in one that causes permanent disability, there is a direct loss, to the industry and to the state, of the strength and ability of a workman (skilled or unskilled). It does not appear that the monetary (consumption) value of an industrial worker to the state has been estimated in this country.

In accidents that cause only temporary disability there is a direct loss in the waste of time; there is also the loss of productive labor, and in some cases a further loss to production due to the stoppage or slowing-down of machinery (especially in factories) when an accident occurs.

Industrial Economics

The principle of occupational risk, as distinguished from what is known as "liability in tort" (injury to person) under the common law and from "liability by contract," has been accepted in almost all modern laws on workmen's compensation. Payments due on account of industrial accidents are now reckoned as part of the overhead costs of almost all industrial undertakings, just as repairs and depreciation.

The recognition of this liability produces, or should produce, the following very desirable results: (*a*) intensive and sustained effort for the prevention of accidents; (*b*) organized first-aid work; (*c*) surgical and rehabilitation treatment subsidized by employers. It is now generally admitted that it is sound business to put up money for the treatment of accidents by all modern methods that will minimize or abolish a disability, rather than pay a lump sum for compensation or a pension over a long period.

The injurious effects on the morale of the workmen of frequent accidents is an item that should not be forgotten; the dismal procession of disabled natives proceeding from the South African mines cannot but have an untoward effect on the minds of the native population.

Surgical Progress

The value of first-aid work to industries has been conclusively proved, and a consideration of its organization on modern lines is certainly called for. Modern surgery in its treatment of injuries tends more and more in the direction of conservatism and orthopedics, combined with all the various forms of physiotherapy. The lessons of the war must not be forgotten and the valuable work done in rehabilitation of the disabled and reeducation of the maimed is of the

greatest service in the treatment of industrial injuries. In America and Europe, industrial clinics are rapidly proving their usefulness in the prevention and early detection of conditions that may occasion accidents.

A project, therefore, that is in accord with humanitarian principles, that contributes to international legislation, that diminishes financial loss, that is a factor in industrial economics, and that makes for surgical progress is one worthy of consideration in connection with the rehabilitation of the industrially injured; and it is along such broad lines that the subject needs to be handled if a satisfactory plan for treating industrial injuries is to be evolved. It is practically impossible to suggest details for one inclusive scheme that will be applicable to conditions so extremely diverse as exist in South Africa. Three main difficulties are, for example: (1) concentration, as exemplified on the Witwatersrand, where 17,000 whites and 170,000 natives reside in an area of less than 100 square miles; (2) diffusion of the labor force, as is seen on the South African Railways & Harbours, where 36,000 white and 43,000 colored laborers are scattered over 11,000 miles of railway, being more closely settled in certain towns; (3) the fact that none of the factories or works employ any large numbers as compared with similar places in Europe or in the United States.

Certain general principles, however, can be laid down, which are applicable to all conditions.

TABLE 1.—INCIDENCE OF ACCIDENTS AND COMPENSATION PAID TO EMPLOYEES (EUROPEAN AND NON-EUROPEAN) OF SOUTH AFRICAN RAILWAYS & HARBOURS FOR THE TWO YEARS 1922 AND 1923

	EUROPEAN		NON-EUROPEAN	
	1922[1]	1923[1]	1922[1]	1923[1]
Total accidents causing injury to employees	4,900	5,250	4,650	4,900
Number of cases of permanent disablement or death	46	61	44	39
Compensation for cases of permanent disablement or death	£11,500	£18,800	£1,000	£730
Compensation for temporary incapacity (wages or otherwise)	£27,500	£28,500	£4,600	£4,900
Totals	£39,000	£47,300	£5,600	£5,630
Total compensation paid, 1922				£44,600
Total compensation paid, 1923				£52,930

[1] Years ending December 31.

Statistics of Incidence of Accidents and their Cost to Industries

For the proper consideration of the subject, and in order to develop any satisfactory plan of action, it is first necessary to discover the in-

cidence of accidents and their direct cost to an industry.

Large employers of labor in South Africa can be grouped into two classes, government and nongovernment.

The largest sections in the government group are: South African Railways & Harbours, Post and Telegraph Department, Defence Force, Police, Education Department, Civil Service generally, and Grain Elevators.

Under nongovernment employers can be included: (*a*) mines[1]—gold, coal, diamond, and mineral; (*b*) municipalities and power stations; (*c*) factories—explosives, tobacco, furniture, clothing, boot, soap, beer, etc.; (*d*) mills—grain, saw; (*e*) works—timber, engineering, motor, brick, cement, etc.

The following statistics have therefore been collected, and include a few figures of general interest and some details with regard to two of the largest employers of labor in South Africa—the South African Railways & Harbours, belonging to the government class, and the mines, as representative of the nongovernment class.

It will be seen that a sum of approximately £170,000 was spent in the year 1923 and in 1923 to 1924 as the direct outcome of accidents to:

1. European and non-European employees of the South African Railways & Harbours (see Table 1).
2. European employees of seventy mines (Rand Mutual Assurance Company) (see Table 2).
3. Natives on all mines in the Union (see Table 3).

TABLE 2.—INCIDENCE OF ACCIDENTS AND COMPENSATION PAID TO EUROPEAN EMPLOYEES OF SEVENTY MINES FOR TWO YEARS, 1922 TO 1923 AND 1923 TO 1924

(*Total number working, 1922–1923—17,000; 1923–1924—18,000*)

	1923[1]		1924[1]	
	Number of Cases	Amount	Number of Cases	Amount
		£		£
Totally but temporarily incapacitated	1,460	20,000[2]	1,780	25,500[2]
Totally and permanently disabled	8	4,500	7	5,750
Partially but permanently incapacitated	120	29,000	125	30,500
Fatally injured	31	15,000	29	15,500
Totals	1,619	£68,500	1,941	£77,250

[1] Years ending March 31.
[2] Including half wages.

[1] The mining companies and insurance companies are concerned with injuries to whites and natives; the benefit societies are also interested but only so far as the white workers are concerned.

When to these figures are added the accidents occurring in other works, outside the mines and railways, on the streets and farms, in ordinary houses and shops, and in other places, it will be realized that the monetary cash loss in compensation is a very heavy item.

It needs to be emphasized, however, that the direct loss in compensation and wages is probably only a fraction of the indirect loss to the industry and to the state. The legal and medical expenses, the loss of time, strength, and life, and other factors combine to make the happening of any number of accidents a serious economic matter.

South African Railways & Harbours

The position with regard to accidents occurring on the South African Railways & Harbours is shown in Table 1. This is a government department controlling 11,000 miles of "open" rail, several harbors, and large engineering works, on and in which are employed 36,500 Europeans and 43,600 non-Europeans (native, Indian, and colored laborers).

TABLE 3.—INCIDENCE OF ACCIDENTS AND COMPENSATION PAID TO NATIVE LABORERS ON ALL MINES FOR TWO YEARS, 1922 AND 1923

(*Total number working, 184,000*)

	1922				1923			
	Number of Cases	Amount			Number of Cases	Amount		
		£	*s*	*d*		£	*s*	*d*
Compassionate awards[1]	1,025	3,444	9	2	1,148	3,794	17	..
Permanent partial[2] incapacity	845	12,627	15	..	699	13,792	..	..
Permanent total incapacity	31	1,324	10	..	30	1,417	10	..
Fatal accidents	446	14,815	..	..	522	18,665	..	..
Totals	2,347	32,211	14	2	2,399	37,669	7	..

[1] Compassionate awards are made in respect of native laborers who are not permanently incapacitated in terms of the Act or in cases where compensation is not payable owing to serious and wilful misconduct.

[2] There must be an incapacity of 10 per cent. before compensation can be assessed.

Mines

European Compensation.—The figures given in Table 2 show the number of European cases receiving compensation as a result of accidents occurring on seventy mines that insure their workers with the Rand Mutual Assurance Company. This Company is entirely financed by the various groups and mining companies whose employees it covers. The figures given include compensation, legal and medical expenses, and sick pay (or half wages) to the injured. The amount of compensation is decided by the Company on the percentage of incapacity as assessed by its medical officer and is paid in a lump sum. By

the Workmen's Compensation Act (South Africa) the maximum compensation payable to a European for death or total permanent incapacitation is £750; for partial permanent disability, £375. The Company pays half wages to any employee who is temporarily disabled during the whole time that he is off work. It also pays all hospital expenses after the tenth day; up to that time they are met by the benefit society to which the injured man belongs.

Native Compensation.—The figures given in Table 3 have been supplied by the courtesy of the director of native labor, and show details of compensation paid to native laborers on all mines as a result of accidents.

Shifts Lost.—Another very important factor in the consideration of the economic loss due to accidents is the matter of actual shifts lost. The figures given in Table 4 have been extracted for ten representative mines for the four years 1912, 1917, 1921, and 1923, and show the actual number of days of incapacity through accidents reported and nonreported (to the government mining engineer) for natives only.

TABLE 4.—DAYS INCAPACITATED THROUGH ACCIDENTS REPORTED AND NONREPORTED FOR NATIVES WORKING ON TEN MINES FOR THE FOUR YEARS 1912, 1917, 1921, AND 1923

	1912	1917	1921	1923
Average labor strength	66,700	66,200	62,600	66,700
Number of injured employees in accidents reported	795	993	1,467	1,354
Number of injured employees in accidents nonreported	21,918	18,188	23,053	22,194
Days incapacitated from reported accidents	39,000	35,000	113,000	64,000
Days incapacitated from nonreported accidents	378,000	319,000	376,000	294,000

Any accident must by law be "reported" to the government mining engineer: (*a*) when it causes or is likely to cause death, or permanent (partial or total) incapacity; (*b*) if tetanus or serious sepsis supervenes or is likely to do so; (*c*) if the patient will probably be in the hospital for fourteen days or more; (*d*) should the patient have remained in the hospital for thirty days, and not been previously reported.

The average native accident case admitted to a hospital spends fifteen days in the wards. It is found, further, that 54 per cent. of the total morbidity of mine natives and 20 per cent. of their total mortality is due to accidents.

Prevention of Accidents

The legal definition of an accident is "an unlooked for mishap or untoward event which is not expected or designed." Although the prevention of these "unlooked for mishaps" may not come within the strict and literal limits of the subject, it cannot be altogether omitted in any consideration of industrial injuries, particularly when a plan is included which large

employers of labor may use in dealing with such accidents.

Obviously, the better the organization for the prevention of accidents, the less necessary do plans for treatment become. A summarized statement is therefore given of modern methods that are being adopted to this end; many of these methods are in use in South Africa; some others, however, may be unknown, as yet, and might with advantage be introduced.

Desirable methods may be indicated under the following headings: legislation; examination and elimination; investigation; classification; education; administration.

Legislation

Legislation for the promotion of safety and for the improvement of working conditions is of the utmost importance. This includes all such matters as the guarding of machines, limitation of congestion of the labor force, lighting, regulation of hours, fencing, safety appliances, control of explosives, examination of ropes, gates, etc. When laws in this direction are made, a government department which supervises the due carrying out of the regulations and which prosecutes those who break the law is a very obvious corollary, but one which, in some places, still needs to be supplied. It should be remembered, however, that a superfluity of regulations means that they may be disregarded and may lead, perhaps, to more danger than if they did not exist.

Examination and Elimination

A careful, preliminary medical examination of all employees is desirable, especially of those who may have to work with machinery and explosives or in dangerous places. Such an examination is a matter of routine on the South African Railways and in other public services before candidates are accepted for employment. Natives on the mines also undergo a preliminary examination and subsequent monthly weighings; and Europeans who desire to work underground are examined as to their fitness from the point of view of possible silicosis.

These initial examinations should be supplemented by periodic inspections so that those who become so incapable or unfit as to cause danger to themselves or to others may be eliminated.

Such matters as eyesight, deafness, epilepsy, the alcohol habit, color vision, and general intelligence are of special importance in such examinations.

Investigation

If the repetition of accidents is to be prevented, an early inquiry by government officials must be made into every serious accident, with a report as to the surrounding conditions together with the obvious or possible causes.

Classification

A systematic study of causes, with regular records of all accidents occurring on the plant or property, and a careful subsequent analysis of these records, will go a long way toward removing causes that are removable, noting sections and shops which have an abnormal accident incidence and thus promoting prevention. Records should not be too complicated, as

overloading with unnecessary details eventually promotes inefficiency.

The essential points to be noted are: (*a*) frequency of occurrence; (*b*) position—geographical (on the mine or works), anatomic (on the body); (*c*) severity; (*d*) causation.

Education

Much can be done in the direction of the positive education of laborers with regard to the principles and advantages of safety. Some methods for so doing are the following:

The provision of safety-first periodicals. These should be well edited, "live" papers containing up-to-date matter of varied interest and illustrations, together with articles and paragraphs on accident prevention. Competitive graphs of accident incidence between firms in the same industry or between sections on the railway might well be included. The paper should be supplied free of cost to the employees, but the actual distribution needs to be well organized, otherwise stacks of old copies will be found on office shelves or floors.

The publication of "safety" articles in the daily press is a valuable method of propaganda. Talks on this topic by broadcasting agencies also provide an effective method of publicity.

Posters, having a clear letterpress, interesting diagrams, and convincing pictures prove a valuable way by which workers can be educated. Care must be taken to print correct translations in the languages understood by the people concerned. Bulletin boards for these posters are necessary, and can be used in offices, compounds, hospitals, shops, shaft heads, pay offices, recreation halls, change houses, and the like.

The insertion of safety slogans and sermonettes in the pay envelopes is another useful method of bringing the point home, and the use of safety button badges is possibly a useful adjunct.

Lectures and demonstrations by trained people to groups of employees are often very efficacious. These may be illustrated by papier-mâché models of smashed limbs, by lantern slides, by specially prepared bioscope films, or by the actual demonstration of accidents, their avoidance, or results.

The question of interesting the wives and children of employees in the advantages of safety first opens up an interesting field for discussion and experiment.

Administration

The appointment of safety committees in all sections of the factory, railway, or mine is an essential part of administration. Such committees should be elected by vote of the employees, be responsible to a central committee, and change their personnel at regular intervals.

"Brain-wave" bonuses or the payment of cash as prizes for useful safety suggestions offer a valuable stimulus for the development of ideas. The arrangement of periodic competitions (as to the number of accidents, death rate, etc.) between sections, departments, factories, mines, etc., and the provision of suitable prizes, has been proved to be of great use.

A systematic inspection of machinery, working places, and works generally from a safety point of view is most valuable, and can be done either by the

company's engineer, by a friendly critic, by a paid specialist, or by a government official. Employees should be encouraged to call attention to dangerous places.

The regular use of warning signs (without unnecessary words) is important, for all dangerous places. A system of fines, for proved cases of carelessness, may be possible. Prosecution for deliberate infringements of the law should be not only possible, but the expected and inescapable result of such infringements.

Another important point is the thorough training of all officials, overseers, bosses, and foremen in the principles and practice of prevention.

Organized co-ordination between the manager and the heads of departments is a prime factor in a successful campaign.

The provision (free or at reduced rates) of safety overalls, goggles, helmets, boots, shinguards and other items of clothing, is a further matter that calls for consideration.

Education and administration must not be unduly pushed, or a feeling of opposition rather than co-operation may be produced.

Organization of First Aid

In an accident, as in a fire, it is the first few minutes that count. Early and efficient first aid is an essential factor in the treatment of industrial injuries, and the thorough organization of such work becomes a paramount necessity. This involves and includes the following matters: popularizing the movement among employers, employees, and their families; notification of accidents; transport of the injured; staff, equipment, and quarters for first aid; supervision by medical officer and maintenance of records; and co-ordination.

Popularizing the Movement

In view of the apathy of some, and the antipathy of others, toward first aid, deliberate measures need to be adopted in order to make the work popular and to keep it so. To this end such methods may be adopted as: (*a*) attractive classes for employees addressed by qualified lecturers and trained demonstrators (a dull lecturer quickly kills interest); (*b*) encouragement of trained men in keeping up their efficiency—by team practices, tallies, first-aid evenings and demonstrations, and the payment of an annual bonus to men who pass a special test; (*c*) regular use and proper distribution of picture-posters, diagrams, and magazines on first aid; (*d*) encouragement of the movement by the personal example and interest of directors, owners, managers, and foremen; (*e*) organization of local and district competitions between picked teams.

Notification

Speedy and satisfactory notification of every injury that receives a first-aid dressing is of prime importance. Arrangements should be made so that the person who does the dressing notifies the foreman or ganger of the injured worker, and also the ambulance depot or dressing station.

The injured man must be instructed to report to the depot for inspection and further dressing if need be, and, should he fail to do so, the depot must notify the management of such failure.

Such a scheme does not involve any complicated machinery but can easily

be worked by each first-aid dresser carrying a small book of tickets with tear-offs on which is written the name (or number) of the person dressed.

In more serious accidents it becomes necessary to notify the nurse or ambulance officer, the doctor, and the local hospital at once. The availability of an efficient telephone system, is, of course, essential. The later notification to the management, to the authorities, and to the insurance company does not come within the scope of first-aid organization.

Transport System

Emphasis needs to be laid on the great importance of the speedy transfer of the more serious accident cases to a place where warmth, restoratives, and skilled treatment are at once available. Delay in such transfer too often results in severe shock and possible subsequent death.

Stretchers, plank and canvas, that can be carried by hand or placed on wheels or trolleys must be provided at strategic points. A motor ambulance is an essential where the area to be covered is large or where the hospital is not close to the works.

Staff

A whole-time, fully trained, easily available ambulance officer (male or female) is a necessity on every up-to-date plant where there are many employees. This officer should, under the direction of the medical officer, superintend all the first-aid workers, equipment, and depots on the property, should act as demonstrator for lectures and trainer of teams for competitions, and be called on to take charge of any serious accident that occurs.

On mines and similar large plants there should, in addition, be part-time workers, stationed at strategic points, who are paid a retaining fee or bonus to act as shaft, shop, or local ambulance officers. Where there are female employees in any number, the services of a trained woman nurse are highly desirable.

A team or teams of trained men (or women) should be organized in all large factories, mines, and works. Such a team should be available in any emergency and should be allowed to choose its own captain. Break-down gangs on the railways should contain experienced first aiders. A certain proportion of foremen and ordinary workers should be taught elementary first aid, so that there is available in every room in a factory, in every level in a mine, and in every shed in a shop, at least one person who knows how to dress a wound, fix a fracture, stop bleeding, and do artificial respiration. In dangerous places, such as underground workings, a first-aid package could well be carried by every white worker.

During recent years in the Transvaal mines 6,000 native boss boys have received training in elementary first aid. They carry and use dressings and bandages and can stop hemorrhage, apply splints, and perform artificial respiration. The results of such organized first aid are highly satisfactory

Equipment.—In an emergency, first-aid workers can use what is available at the moment but for really efficient work certain apparatus must be provided. First-aid wallets or small metal boxes should be carried by trained persons who are with gangs at a long distance from skilled assistance. On construction works, in

underground workings, and for breakdown gangs such boxes are of particular value. They should be strong, water-tight and contain first-aid packets, bandages, a tourniquet, and a small bottle of antiseptic lotion. Larger boxes should be readily accessible at railway stations, in trains, and at suitable places in mines, factories, quarries, and works. Such a box should be in charge of a specified person and easily carried by one person; its key should be readily obtainable, and the contents should be splints, tourniquet, bandages, dressings, emetic, stimulant, and antiseptic in adequate quantities.

In the emergency depots (described later under *Quarters*) should be found the following equipment: stretchers, pillows, blankets, oxygen cylinders, tables, buckets, basins, instruments, towels, dressings, bandages, first-aid packets, tow, splints, tourniquets, antiseptics, and a large, metal first-aid box. A Thomas' knee splint is also desirable.

Some scheme must be devised by which, in every case of injury, the systematic and immediate use of the first-aid equipment is insured, especially in cuts and wounds. It is better that such use should be automatic and voluntary rather than that it be enforced by a system of fines for neglect.

First-Aid Dressing.—The ideal first-aid dressing should take the form of a package of suitable size in an impermeable cover. It must be easily opened and applied and should remain in position for some time. It must be sterile and remain so until applied. Its cost should be as low as is consistent with efficiency.

In view of the fact that in every industrial injury the wound is surgically a "dirty" one, and therefore potentially septic, the addition of an antiseptic is necessary. This antiseptic should be stable in its composition, nontoxic, analgesic, osmotic, of definite and constant germicidal strength, and, if possible, should be incorporated in the actual material of the dressing so that no special container is necessary.

It is estimated that over 500,000 first-aid dressings are now used every year on the Witwatersrand gold mines alone, so that the perfection of such packages is by no means an unimportant item, and its relationship to the treatment of industrial injuries is a very vital matter.

Quarters.—Any factory, mine, or other works that plans for a properly organized first-aid department must provide proper quarters where accidents can be satisfactorily dealt with. One or more emergency depots are called for at strategic points on the property, equipped with the appliances detailed above; these depots are especially necessary when the hospital is at some distance from the works.

Such a room must be easily accessible, and should have a broad doorway for the speedy admission of a stretcher and its bearers. The room must be well lighted, well ventilated, and properly heated. The walls and floor must be of impermeable, washable material and the place should be used only for the treatment of accidents. It should be in charge of a trained nurse, or ambulance officer who is responsible for the upkeep and cleanliness of the apparatus, as well as for the treatment of all cases brought to

the room. This officer should be on duty when the workers are going off shift so that he can dress all minor injuries that are presented for treatment.

Supervision and Records

The constant supervision of the whole organization by the medical officer in charge is highly necessary. If 100 per cent. efficiency is to be obtained, he must not only arrange his plans and issue his instructions, but he must personally see that they are being carried out. Inspection of depots and boxes at irregular and unexpected intervals, systematized records and regular returns, reexamination for efficiency and other methods will all help in the direction of good results, but his own personal interest in the work and inspiration of the paid and voluntary workers will do far more to maintain a really satisfactory chain of first-aid help that is strong and effective in every link. Such supervision is obviously more possible where a whole-time medical officer is employed.

A list should be kept by the medical officer of all trained persons on the property; their locations should be known, recorded, and checked periodically. A simple system should be devised of recording the issue of dressings and checking the number of those used—*i.e.*, the number of accidents treated by the first-aid staff.

Co-ordination

Co-ordination plays a most important part in the satisfactory organization of first-aid work. If there is not a cordial co-operation between the various departments and the medical staff, if the management does not support the medical officer in his efforts, and does not encourage the workers in a proper use of first-aid appliances, much of the work will be unsatisfactory and incomplete even with an otherwise well-thought-out scheme.

The medical officers of an industry can help the movement greatly by conference and mutual advice, and by consultation with the heads of the industry can make many ideas really practicable.

Surgical Treatment

The acid test of all treatment is the rapid and complete restoration of function. The question of the number of lives for which a medical officer is responsible (whether he is on part or whole time) is a factor which vitally affects the whole matter of efficient treatment.

While for convenience of description the purely surgical treatment of accidents is separated from the physiotherapeutic methods, it must be strongly emphasized that in most cases both forms of treatment are necessary, one being the complement of the other. The more perfectly both measures are carried out, the less necessary do rehabilitation centers and special orthopedic departments for after-treatment become.

Minor Injuries

Under minor injuries may be included those not necessitating absence from work but needing more than the mere first-aid dressing. The decision as to whether any particular injury

should, or should not, justify abstention from work must rest in the hands of an experienced and qualified person.

The treatment of such injuries involves, in any large works, the provision of a dressing station, or ambulance depot, to which all minor accidents are reported and which the injured persons can attend daily for dressing. This room should be situated near some exit used by the majority of the workers, and every encouragement should be given for its systematic use by those who have been injured with cuts, bruises, sores, grazes, etc. Such a depot must be well lighted and kept thoroughly clean, be open at suitable and regular hours, and be in charge of trained workers and under the direct supervision of the medical officer.

A record of the attendances of those injured should be kept and no one should be allowed to discontinue treatment until "signed off" by the person in charge. All cases not doing well should be detained for the inspection of the medical officer, or sent at once to a hospital.

The dangers of sepsis as a result of even very small injuries must be carefully explained to all employees, especially to first-aid workers, and those who apply the subsequent dressings must always keep this point in mind.

On mines and in other places where the employees live on or near the works the provision of a trained female nurse is a very desirable factor in treatment. She could reside on the property and be a whole-time, paid agent of the company or of the sick benefit club, or be paid a retaining fee and a fee for each case treated. Her work would be to do daily dressings for minor injuries, to massage patients as directed by the medical officer, either in their homes or at a central room, and to do other home nursing as time permitted and occasion demanded.

The kind of dressing used in cases where the patient continues at work is by no means an unimportant factor. Many of the points made in connection with the ideal first-aid dressing will also apply here. Healing qualities (antiseptic and osmotic), together with ease of application, smallness of bulk, initial cost, and a tendency to "stay put" rather than to slip off are the most important factors.

The following, in the experience of the writer, has been found to be the most satisfactory dressing, both for first aid and for the daily dressing of minor injuries, though it does not possess all the desirable qualities mentioned in a previous paragraph: lint, with a thin layer of cotton wool inside a covering of jaconet and saturated with a solution of 1 in 80 Hycol,[2] and the whole applied with a roller bandage.

Injuries Resulting in Absence from Ordinary Work

Apart from death there are four possible degrees of such absence.

1. Partial Temporary.—The injured person cannot perform his usual duties, but is able to do light or part-time

[2] The American editorial office is unable to trace this particular preparation and opposes the use of proprietary substances of similar type. Owing, however, to the fact that Dr. Hertslet's paper comes from a distance and portrays practice in an active industrial center, this reference and others of similar type have been allowed to remain in the text. The standard first-aid antiseptic in the United States is 3 per cent. tincture of iodine dropped into the wound and painted over the adjacent skin, followed by a dry sterile gauze dressing.

work while regaining the use of the injured limb. There seems to be a growing opinion that such an arrangement should be made in every possible case, and that it is a feasible proposition in many more cases and places than has previously been imagined. In some industries the following principles are gradually being accepted:

a. The reception of an injury does not confer the right to idleness.

b. Every injured person is morally entitled to go on earning with whatever function he possesses.

c. Continuance at work (on full pay), although it be of a less strenuous nature, is often better for the injured person, and for the employer, than half pay, idleness, and possible compensation.

d. Such work should be done with the approval of the medical officer, and it must in no case be allowed to retard the complete recovery of function.

e. Facilities for such an arrangement should be deliberately provided by all large employers.

f. Although financial considerations must necessarily enter into any such plan, they should not be allowed to govern the situation.

2. Total Temporary.—Here there is a return to full work after a period of total incapacity; this obviously may be varied by a return to light work before complete recovery is reached.

3. Partial Permanent.—In this case the patient is never fit to do his original form of work, but becomes capable of doing other work of a lighter nature.

4. Total Permanent.—The injured person is quite unable to do work of any kind. Henry Ford points out that in fully organized works such a condition is comparatively rare, that work can and should be found for men who have lost both eyes or both legs. In his plant at Detroit about 9,500 crippled or diseased men have been admitted. Among these there are working 123 men who have suffered amputation of arms, forearms, or hands or who are hopelessly crippled in one of these members, 4 totally blind, 207 blind in one eye, 37 deaf and dumb, 60 epileptics, 4 with legs and feet missing, and 234 with one foot or leg gone. All are earning by actual work done the standard wage for their job or more than the standard wage.

Before proceeding to a more detailed discussion of treatment it must be noted that due provision for exact diagnosis is always necessary. The systematic use of X-rays is due both to the patient and to the practitioner, particularly for strains, sprains, fractures, and dislocations. Stereoscopic plates should be made at as early a stage as possible and again as the case progresses. The use of electricity for the discovery of injured nerves and paralyzed muscles is also necessary.

The prevention and treatment of shock is an essential part of the treatment of industrial injuries, for the most scientific attention to the site of the injury is futile if in the meantime or later the patient dies of shock. Surgical shock is said by some authorities to be due to diminution of (*a*) body temperature, (*b*) blood pressure, and (*c*) blood volume. It may be primary or secondary. In the former state the usual clinical signs of collapse occur immediately after the injury; it is especially common where the muscles are severely injured. It is aggravated

by bleeding, loss of body heat, pain, disturbance, and fear or other adverse mental condition. Secondary shock is seen at a later stage, particularly if treatment is delayed and the patient is exposed to cold. The toxemia of muscle injury, continued pain, operations, and anesthetics (especially chloroform) are further contributory causes. A combination of nitrous oxide and oxygen has been found to be the best anesthetic for such cases.

For the prevention and treatment of the condition of shock the following measures are useful: (1) warmth—which includes hot blankets, a heater under the stretcher in the ambulance room, hot bottles (especially between the legs), and hot drinks; (2) obvious measures, such as relief of pain (by a hypodermic injection of morphia), raising the feet, and stopping of hemorrhage; (3) the intravenous injection of 500 c.c. of a 6 per cent. infusion gum acacia solution, or glucose, or bicarbonate of soda; (4) hot saline injections per rectum.

The suitable treatment of hemorrhage is usually self-evident and may be briefly summarized as follows: (1) the direct pressure of (*a*) pad and bandage or (*b*) plugging and bandages—with a splint to the opposite side of a limb so as not to block the main arteries, or (*c*) forceps (artery); (2) ligature; (3) lastly, and only as an emergency measure, a tourniquet.

Treatment of Particular Injuries

Large Septic Wounds.—The modern practice with regard to these varies according to the condition found and the predilection of the surgeon, and may be summarized as follows: (*a*) early operation under an anesthetic and under aseptic conditions, as soon as the patient has recovered from primary shock; (*b*) wide exposure of all the injured surfaces, including intermuscular pockets; (*c*) removal of all devitalized tissues (leaving as much skin as possible), bits of clothing, bullets, stones, and other foreign bodies; (*d*) thorough cleansing of the whole area by a vigorous use of antiseptics such as Hycol, ether, Dakin's fluid, or peroxide of hydrogen (these should not be too strong, especially where complete excision is impossible); then, either (*e*) immediate suture and complete closure or (*f*) suture delayed for a few days so as to insure asepsis; (*g*) secondary suture—*i.e.*, closure of the granulating area when free from bacteria; (*h*) if not closable, (1) prolonged contact with a mild antiseptic such as Dakin's fluid, eusol, flavine, or bipp, either by Carrel's tubes, or by gauze plugs soaked in lotion or ointment, (2) prolonged contact with saline solution; (*i*) free drainage.

The causes of sepsis are sometimes unavoidable—such as dirty skin, clothes, and working conditions; they are more often avoidable—these include the lack of speedy and efficient first aid, and careless, or wrong, later treatment. The results of sepsis may be one or more of the following: scarring, pain, stiffness, delay in recovery, expense, ankylosis, amputation, septicemia, and death.

Every accidental wound is potentially or actually septic, and should be treated as such, initially and later.

Fractures.—The ideal result of a well-treated fracture is perfect alignment combined with speedy and complete restoration of function; this includes such matters as strength, mobility,

and endurance, and a total absence of pain or tenderness. It must be remembered that the eventual efficiency of a fractured limb is more important than a perfect alignment.

The older methods of prolonged and rigid rest by means of splints and plaster of Paris are giving way to those which include such physiotherapeutic measures as stroking, massage, heat, electricity, and early passive movements (followed as soon as possible by graded active ones) particularly in the upper limb, when not in the neighborhood of a joint. By such means the muscular spasm is rapidly relaxed, an increasing tone is soon gained, and the length of time for which joints need to be immobilized is much lessened. Provided that the intelligent cooperation of the patient can be obtained, the use of splints can be discontinued after ten or twelve days, and in some case may not be called for at all.

Heald gives the physiologic grounds for the early treatment of fractures by electricity, particularly by a weak anodal galvanic current; he gives a clinical summary of 150 cases treated by the use of this method as supplementary to splints, rest, movement, etc. Of these, 108 showed complete recovery, thirty-three were not so complete but still had a good result, and nine only were not satisfactory. The total included practically all kinds of fracture. Eighty-five of his cases which received electrical treatment were incapacitated for over fifteen days. He compares this number with 340 in the Royal Air Force and 1,072 reported by the British Medical Association Fractures Committee, both belonging in the over fifteen days' incapacity group. The average number of days of incapacity in each group was 45, 69.3, and 172, respectively.

Joint Injuries.—Wounds involving a joint, especially when that joint is the knee, offer especial difficulty. Various methods are advocated for dealing with a septic knee joint. The more commonly used are as follows: (1) early operation, with excision of the infected tissues, and aseptic closure of the synovial cavity and suture of the skin, together with drainage down to, but not into, the joint cavity for twenty-four hours, and careful fixation in a Thomas' knee splint; (2) lateral incisions and rubber tube drainage; (3) lateral incisions, irrigation, drainage by strands of silkworm gut and fomentations; (4) reflection upward of a V-shaped flap, including the patella, and subsequent drainage; (5) excision of the joint; (6) aspiration and leaving a solution of gentian-violet in the joint; (7) injection of alcohol (s.v.r.) after flushing out with saline solution.

It seems highly possible that the varied results obtained in the treatment of septic knees are due to the varied cocci causing the trouble; *i.e.*, a joint infected with streptococci may clear up under ordinary treatment, while a staphylococcic infection might need amputation, or *vice versa*. An inquiry into this point might lead to valuable results.

Muscle wasting also follows joint injury and must be combated by physical means.

For the prevention of adhesions in injured joints, heat, passive movements, and massage are of the greatest value. Fibrous ankylosis can often be satisfactorily treated by ionization

with salt. It is very desirable that muscular function should be restored by massage and electropathy before adhesions are broken down in stiff joints. It is important to know the exact position at which a joint should be fixed, when such a measure is necessary, so that the greatest amount of utility can be obtained. The best positions are stated to be as follows:

Shoulder: abduction at 60° with the arm slightly forward.

Elbow: flexed at an angle of 70° to 90°.

Hip: very slight abduction, with the thigh extended, and slight outward rotation.

Knee: extension.

Injuries to Muscles and Tendons.—When muscles are torn by an injury, there is a grave possibility of serious toxemia and resultant shock. The most useful form of treatment for injured muscles is electric stimulus; it appears, however, that the desired restoration of muscle tone is brought about more by the actual contractions of the muscles themselves than by the stimulus of the current. Much valuable work has been done by surgeons for the restoration of function by suture and transplantation of tendons.

The psychic side of the reeducation of motor impulses is most important in dealing with paralyzed muscles. A valuable part is played by the masseur in this matter, and the particular mentality that is necessary seems to be a special gift, permitted by the gods to only an elect few.

Eye Injuries.—The treatment of eye injuries must be carefully performed if severe disability is to be avoided. The use of a 4 per cent. cocaine or 3 per cent. novocaine solution is a valuable preliminary to the removal of a foreign body; this can be followed by gentle syringing with saline or with boracic acid solution.

Any foreign body that cannot be removed by a camel's-hair brush, or by a pointed match (on which cotton wool has been wound), must be sent to a medical man, who alone should be permitted to use an eye-spud. If the cornea is wounded, borated vaseline and a cold compress form the most suitable application. Arrangements should be made for the early and proper consultation with an eye specialist in all conditions beyond an ordinary foreign body which is easily removable.

Burns.—The early and systematic use of picric acid is the most important measure in the treatment of burns. Arvem[3] is a modern preparation that has a great healing capacity. The prevention of bad scarring and contractures is by no means an easy matter, particularly on the face and at the flexures of the body, but vigorous antisepsis and physical remedies, followed, if necessary, by skin-grafting, will meet the need in most cases.

Plastic Surgery.—As a result of the vast experience gained during and after the great war, plastic surgery, particularly of the face, has made wonderful strides.

The chief conditions that determine successful results seem to be the following: (*a*) the obtaining of primary healing by means of strict asepsis; (*b*) spraying the wound with peroxide and eusol; (*c*) accuracy of adaptation

[3] The editors are unable to identify this preparation. A standard ointment for use in burns given by Dr. W. I. Clark is 3 per cent. sodium bicarbonate in petrolatum.

of flaps and grafts whether pedicle, "caterpillar," or "tubed;" (*d*) avoidance of raw surfaces; (*e*) use of the patient's own tissues, autogenous grafts, and the like, rather than of foreign substances.

Injuries to the Back.—Sprains, strains, contusions, dislocations, and fractures of the back provide a considerable percentage of industrial injuries. Subluxation of the sacro-iliac joint is a lesion not to be forgotten.

A pitfall for the unwary is to be found in the X-ray appearance of the normal fifth lumbar vertebra, as in many normal cases where no lesion exists the plate seems to show some abnormality of position or density.

Hernia.—The question of hernia is always a difficult one. When an employee claims compensation or free operation on the ground of a rupture caused by a sudden strain while at work, it is almost impossible to prove that such is not the case, and the man is usually given the benefit of the doubt. There are some authorities who believe that all hernias are primarily congenital in origin, but there can be little doubt that many develop as a result of strain. If every employee were examined for hernia as a part of the initial routine examination before engagement, much of the difficulty attending these cases would be obviated.

Treatment of Malingering

This is an important phase of the whole question of injuries, as certain people who are liable to industrial injuries are prone either to feign a lesion that is purely imaginary, or to persuade themselves, their friends, or their medical attendant that the results of a real injury are much more serious and prolonged than is actually the case. A claim for compensation is at the root of many such conditions, but is by no means the reason for all. Laziness, a desire for sympathy, or a morbid psychic state may be, and often are, the exciting or contributory causes. The line that may be drawn between psychogenic symptoms (pain, anesthesia, etc.), traumatic neurasthenia, real hysteria, and actual malingering is both tenuous and tortuous. Meticulously careful examination, supplemented by a knowledge of the many technical points laid down in the textbooks, will generally suffice for the discovery of conscious or subconscious fraud.

Treatment practically resolves itself into the exclusion of all possible pathologic causes of the alleged symptoms, followed by a clear and tactful statement, to the employers, to the solicitors, or to the patient, of the conclusions reached. Such action, combined with independent consultation, will usually have the desired result of a speedy return to work and avoidance of compensation.

Traumatic Neurasthenia.—Any functional disability, where no physical nor pathologic cause can be discovered on careful, scientific examination, may be put under this category, deliberate malingering having been duly excluded. In many cases of railway spine and other similar conditions the only real cure seems to be compensation. The most satisfactory form of treatment for ordinary cases is a due proportion of psychotherapy and physiotherapy, combined with general tonics, fresh air, and a suitable dietary.

Artificial Limbs

It is probably the usual custom—and certainly such a practice should be the rule—that artificial limbs should be supplied as an integral part of the compensation. The question of their subsequent upkeep, repair, and supply of new ones when the old limbs are worn out must be a matter for arrangement in each case.

With regard to the upper arm, obviously the stump should be as long as possible, but an efficient apparatus can be fitted if only one-third of the upper arm is available. In the making or choosing of an artificial hand the following points should be kept in mind: It should be strong, adaptable to various needs and conditions, easily fixed and easily removed. In all such cases the patient should be taught to use the natural uninjured arm for all purposes, using the artificial limb as an auxiliary.

It is possible, however, by perfecting the co-ordination of all intact muscles and by educating tactile, muscular, and joint sensations, that the patient will become able to perform definite and even complicated exercises with either upper or lower limb.

A strong, light limb is an essential, and graduated exercises under skilled direction are necessary if such efficiency is to be attained.

Physical Treatment

Under this title are included most of the more modern forms of treatment which do not involve the use of the knife or of drugs. Emphasis needs to be laid on the value of the early use of such treatments in industrial injuries, as they supply the needed physiologic help to the mechanical and surgical methods that are generally employed.

The following brief account is necessarily limited to those forms which are of service in traumatic conditions and their after effects. A decision as to the proper combination, sequence, and duration of these various measures can be arrived at only after careful examination and weighing of all the signs and symptoms exhibited; the cumulative effect of such intensive and persistent treatment has been proved to be very great in the prevention of disability and the rehabilitation of the incapacitated.

Functions of Physiotherapeutic Department

Modern industrial conditions and the development of this branch of medical science have made the establishment of physiotherapeutic departments both possible and necessary. Such departments are the complement of ordinary surgical work and of orthopedic clinics.

Some indication of the functions of such a department is desirable and is here submitted—as far as industrial injuries are concerned: (1) careful, scientific examination of the disabled; (2) definite diagnosis of the actual condition by means of (*a*) X-rays for fractures, dislocations, strains, etc., (*b*) electrical reactions of muscles where nerves or tendons may have been severed, and (*c*) other methods; (3) measurement of incapacity—initial, intermediate, and terminal; (4) discovery and elimination of malingerers; (5) early treatment of sprains, bruises, wounds, fractures, and other lesions with a view to prevention of

disability; (6) restoration of function (when diminished or lost); (7) re-education of the maimed. A physiotherapeutic department would also have wide scope for useful work in the supplementary treatment of many diseases, such as rheumatism, pneumonia, neurasthenia, etc.

It cannot be too strongly emphasized that the main purpose and chief value of physiotherapy lie in the prevention of the incapacities so often caused by injury rather than in the removal of such sequelae as scarring, wasting, stiffness, contractions, and deformities.

Organization

The exact lines along which such treatment can be organized must, of necessity, vary considerably according to local conditions. Some of the possibilities are here outlined:

1. Where a works hospital has a sufficient number of accident cases and is at a considerable distance from other works or a central hospital, the initial expense and cost of upkeep of a special department for physiotherapy are justified. In such a case the medical officer will need to be acquainted with modern developments along this line of treatment, and it will be necessary to have on the hospital staff a person who has been trained to give massage and who has a good working knowledge of electrical, water, heat, and mechanical therapy. Such an arrangement possesses the very great advantage of the early and continuous treatment of injuries by the physical methods.

2. Where mines or factories are sufficiently near to one another for the satisfactory use of a central depot, such a center may prove the best working arrangement. It would need to be easily accessible by ambulances and should have a sufficient number of beds available, otherwise only ambulatory cases could be treated. It should be under the control of a practitioner who has specialized in this form of work, and should be staffed by trained persons.

It might be possible for the medical officer of the center and certain of his aides to visit the hospitals of the industry within a certain area at the request of the local medical officer. He should examine and suggest special treatment for such cases as could not be moved, and the treatment, when so desired, could be applied by a visiting, or traveling, aide.

3. Where neither of the preceding plans is feasible and a physiotherapeutic department exists in a central general hospital, it should be possible to send suitable cases to such a hospital.

4. For insurance firms and for private patients and in some ordinary industrial accidents, the services of a specialist who has his own clinic and apparatus could be utilized.

Equipment and Cost.—In the matter of equipment it is impossible to dogmatize, and cost can only be given approximately (for South Africa), but the list given in Table 5 will be found sufficient for the purpose of starting a central clinic where twenty-four cases a day could be treated by two aides working for eight hours. Where such a department is organized in a mine hospital, a more elementary form of equipment could be used and much of the apparatus could be made locally, at a proportionately reduced cost. All

apparatus should be as portable as possible and so designed that it can be taken to the bedside of a patient if necessary.

tures of 260°C. may be obtained, and the whole body may be treated at a temperature of 200°C., without the intervening atmosphere being heated.

TABLE 5.—EQUIPMENT NEEDED TO START A CENTRAL CLINIC FOR TREATMENT OF TWENTY-FOUR CASES A DAY

FORM OF THERAPY	EQUIPMENT	COST
		£ s
	2 couches or plints	10 ..
	tables, stools, etc.	14 ..
Thermo	2 radiant heat baths	7 10
Hydro	1 whirlpool bath	2 10
	4 baths for limbs	4 ..
Mechano	apparatus[1]	10 ..
Masso	1 vibrator	4 10
Electro	1 multostat, pantostat, or plurostat	60 ..
	1 galvanic battery or switchboard	20 ..
	1 Bristow coil	7 10
		140 ..

[1] The appliances that are necessary for the production of those movements that are most often needed and for the education of the corresponding muscles are as follows: ladder (or rib-stall), for stretching the joints and muscles of the back and lower limbs; weights over pulleys, for resisted movements of the arms and legs; horizontal bar, for stretching the arms and back; rotators (including a nautical steering wheel), for adduction and abduction of the arm, and pronation and supination of the forearm; and rollers, for flexion and extension of the wrists.

Methods

Thermotherapy

Moist heat may be applied in the form of ordinary hot water, poultices, fomentations, and the like. Vapor baths, either of water vapor or medicated, are sometimes used for surgical conditions but are not of great value. Dry heat, applied by means of sand, bran, or salt, is occasionally of value. Wax, mud, and paraffin hot baths are also used.

Luminous radiant heat, either by sunlight or by the dowsing-bath system, is the most satisfactory form of external heat application, temperature. This method is specially useful in bruises and sprains.

By the use of the high-frequency electric current, heat is actually generated in the tissues; this is the most efficient method and will be referred to again under diathermy (see *High Frequency* under *Electrotherapy* in this section). The chief action of heat is to produce vasodilatation and thus to lessen muscular spasm, so that by the use of heat the tissues are brought into a suitable condition for receiving massage. Heat also lowers the resistance of the skin, so that higher electric currents can be used. In all inflammatory conditions, for the relief

of pain and the softening of tissues, and particularly in the treatment of nerve and joint lesions, the use of heat is indicated.

Special precautions must be taken when heat is employed over areas of skin that are partly or wholly anesthetic.

Hydrotherapy

This method covers the use of baths of various kinds. Contrast baths—*i.e.*, alternate hot and cold water to a limb—are used for stimulating weakened muscles. Whirlpool baths (a small turbine at the bottom of a tub of ordinary or gaseous water) are valuable in speeding up the convalescence of a shrunken limb due to peripheral nerve lesion; they have a generally stimulating effect and are particularly useful because they can be employed before any other of the physical methods. Pool and shower baths, douches, electrical and medicated baths also have their place in treatment.

The main results of the proper use of baths are that old wounds which have resisted other methods of healing are stimulated in the right direction, pain is relieved, spasm is allayed, absorption is promoted, deep wounds are cleaned and their healing hastened, and the stretching of fibrous tissues and adhesions is facilitated. Obviously, baths should not be used to the point of making the tissues sodden.

Phototherapy

Treatment by artificial light includes the three following methods: (*a*) the ordinary electric light bath; (*b*) the leukodescent lamp of 2,000 candle power; and (*c*) the quartz lamp or actinic ray. All of these are useful in producing vasodilatation and hyperemia in those regions where such a condition is indicated.

Heliotherapy

By heliotherapy is understood exposure of the diseased or of the injured parts of the whole body to the light and heat of the sun. The sun's rays definitely improve the general metabolism; they produce local objective reactions such as pigmentation, perspiration, analgesia, and improvement in function (in stiff joints). Infiltrations are softened, exudates are absorbed, and the expulsion of sequestra is hastened. Rapid cicatrization of ulcers and open wounds is a definite result of the bactericidal action of sunlight combined with a stimulation of tissue repair. Careful dosage is of course necessary to avoid destruction of cells.

Leriche states that in fresh wounds which have been cleansed sterilization is completed in from two to six days. In old wounds when sterilization is once accomplished it is permanent, and secondary suture may soon be done. The phagocytosis and active hyperemia that are induced bring about rapid healing.

Rollier gives a general sun bath, not merely a local treatment of the affected part, and the wound is given a prolonged exposure to the fresh air.

Heliotherapy is also of proved value in fracture cases. It may be applied during the extension of the limb, or when the plaster has been removed. The effect of the sun is to bring about regression of the edema, to strengthen the muscles, to safeguard articular function, to diminish pain, and to favor

the early introduction of passive movements.

How far this method is applicable to the native tribes of South Africa is a matter of interesting experiment, as it appears that the results vary in Europeans according to their response to the sun's rays by pigmentation of the skin.

Mechanotherapy

In this method various mechanical appliances are used for the purpose of producing active and passive movements in the injured parts. The most useful form is that known as the combined Mennell-Sargent apparatus. Zander's machines, which are largely used on the Continent, produce more or less forced movements.

The effects aimed at are the removal of stiffness from joints, tendons, and muscles and the reeducation of wasted muscles so that there is a freer movement over a wider range. A list of the appliances that are necessary for these purposes is given in Table 5. Simple measures, such as the carrying of a bucket, twisting a stick or poker between the fingers, or using garden tools, will have the desired effect in many cases, but the uncommon appearance of a specially designed apparatus has a definite mental effect, and assists that concentration of mind on the muscles being reeducated which is so essential to success.

For stiff fingers Cotton and Sawyer recommend the use of miniature winches or elastic bands which pull for twenty-four hours in the line of the deformity and produce distraction of the joint surfaces. This is followed by a very gradual change of the line of pull toward extension or flexion. They state that the condition of stiff fingers or hands should be rare if such apparatus is properly used.

Musculotherapy

In suitable cases the muscles and tendons are exercised and the corresponding joints and ligaments moved by graduated movements.

Passive movements imply that the patient's muscles are entirely relaxed, and the limb or trunk is moved in the desired direction and degree by the operator.

In *supported active movement* the part is supported while the patient makes voluntary, slow, graduated movements.

Active movements involve the production of similar results without any help or support.

In *resisted active movements* the active movements are continued against resistance supplied by the operator or by mechanical means.

The earlier such movements, particularly the passive ones, are started, the more speedily successful will be the results, and the less likely are adhesions and stiffness to occur. In lesions of the knee joint, early active movements are called for, as soon as possible after operation. In fracture cases the use has been clearly shown of early passive movements in helping the production of callus and in preventing fixation of joints.

As function gradually returns it is highly important that explicit instructions should be given stating exactly and showing in detail how the injured limb is to be used and moved, in order that no wrong movements leading to bad habits may be made. In other words, in every case of injury,

reeducation is necessary; every patient must be shown how to use the damaged part and how properly to reeducate the injured muscles.

Under musculotherapy may also be mentioned such measures as manipulation (of spine and joints), graded exercises, Swedish drill, breathing exercises, and gymnastics, all of which have their particular place in restoring the lost function of muscles and tendons.

Massotherapy

All the varied forms of massage are of the greatest service in the treatment of injuries and their sequelae.

Superficial stroking, which must be soft, slow, and steady, has a reflex action which is particularly useful in the relaxation of muscular spasm and the relief of pain in recent fractures by way of nerve reflex. This is also known as glucokinesis.

Deep stroking must be applied centripetally, must not be forcible, and the muscles of the patient must be relaxed as fully as possible. It removes waste matter by way of the veins and lymphatics.

Percussion includes striking, clapping, and hacking.

By *compression* is meant massage such as the ordinary friction movements, and pinching or kneading.

Vibration includes the action known as shaking. It can be applied mechanically by means of a small motor, known as a vibrator, the better makes of which are so constructed as to give fine, medium, and coarse vibrations.

All these processes directly assist the circulation of the blood and lymph. This promotes the rapid removal of swelling in fractures, strains, and dislocations. These processes also stimulate muscles and improve the general condition of the tissues and thus assist in the restoration of function.

The main results of massage are fourfold: reduction of spasm, relief of pain, removal of swelling, and restoration of function.

Radiotherapy

X-Rays.—Treatment by filtered X-rays, with a dosage graduated according to the depth of the structure to be treated, is of value in the following conditions due to injury: exuberant granulations or callous wounds (without pus), traumatic neuritis, stiff joints, contractions due to scar tissue, and sclerotic conditions generally. It is also useful in subacute inflammatory conditions.

Radium.—Radium has proved valuable in the treatment of injuries involving the wrist and finger tendons, especially after their suture. It also helps to promote healing in extensive lacerated wounds and in burns of muscles.

Electrotherapy

A brief description only can be given of the various forms of electrical treatment of injuries, as many books have been written on this phase of the subject. There are five ordinary forms of electrical treatment: static, or frictional; galvanic, or direct current; faradic, or induced current; sinusoidal, or surging, alternating current; high-frequency, or oscillating current—this includes violet ray and diathermy.

Static Electricity.—This is produced by revolving plates, such as the

Wimshurst machine, or by other means of friction. It is used in either the spark, the breeze, or the static-induced current; the last is the most useful and provides a valuable stimulant in cases of nerve injury.

Galvanism.—Where the ordinary electric light and power supply is direct current, such a source may be used for the purpose of applying electricity in its galvanic form; but where the supply is an alternating current (as it often is), a motor for converting an alternating to a direct current is necessary, or use may be made of dry cells or of accumulators.

The positive pole has a soothing and analgesic action, whereas the negative pole has a stimulating and irritating effect.

Direct current is also used in the process of ionization, where the negative pole drives in the negative radical and the positive pole drives in the positive of a salt. Chemical substances—such as chlorine (used in softening scar tissue) and salicylates (for rheumatism), or iodine (for nerve injuries)—can in this way be driven into the tissues.

The interrupted direct current, using the make and break of a clock or metronome, is valuable for toning up weak or damaged muscle tissue.

It has been found recently that the use of the positive pole (or anodal current) is a potent aid in relieving pain and spasm in recent fractures, and in shortening the period of incapacity.

Faradism.—This is an induced current and is obtained by passing a direct current of low voltage through a coil of wire which magnetizes a soft iron core in such a way that a rapid make and break are obtained. This gives an interrupted current, which induces a current in the secondary coil.

Variations of the faradic current are procured by adding condensers, by employing coils of different lengths, using movable cores, and arranging varying methods of make and break. The Bristow coil is the best, since by its use very small graduations of the current are possible, so that slow, natural contractions of the muscle are caused rather than a series of jerky spasms. Bristow of St. Thomas' Hospital states that he can get the same results that are obtained by an ordinary faradic battery in one-third of the time.

Both galvanism and faradism are used in testing the reactions of nerves and muscles and the faradic current is of real value in strengthening muscular tissue.[4]

High Frequency.—Here a very high voltage, with a very low amperage, is used. The well-known violet-ray apparatus is really a high-frequency current and is supposed to have a bactericidal action; there is, of course, no value in the color.

Ordinary high frequency is now being superseded by the more perfected form known as diathermy. The apparatus used for this purpose has an output of from 3 to 5 amperes as compared with one-half ampere, and it gives one and one-half millions of oscillations per second. This is, for many conditions, the best form of applying heat, as the current creates an active hyperemia and actually generates heat in passing through the tissues. It is

[4] An ordinary faradic battery can be bought for £1.

particularly useful in all inflammatory and painful conditions, it is very soothing when applied to sprained joints, and in fracture cases with delayed union it stimulates the production of callus.

When a high-frequency current is applied to a joint in which there are adhesions, these are softened so that an increased range of mobility can be obtained by passive movements.

Occupotherapy

This connotes the use of directed occupation during the period of recovery, and is especially useful for those persons whose convalescence is prolonged. The mental effect of such a procedure is of the highest value, especially where arrangements are satisfactorily made with regard to payment, which should be considered as wages for work done rather than as charity or compensation from insurance.

The special training given to men disabled by the loss of one or more limbs, or of both eyes, is included under this heading. It should be of such a nature as to fit them for earning a living when health is established.

Psychotherapy

If permanently successful results are to be obtained, there must be a carefully considered combination of the foregoing methods, together with ordinary surgical procedures; to both of these lines of treatment must be added an often unconscious, but none the less definite, form of mental treatment. This is especially necessary in functional disability, and the various points to be considered and methods to be adopted are conveniently included under the heading "psychotherapy" and may be summarized as follows:

The medical man must try to discover and constantly to recognize, throughout the period of treatment, the exact mental attitude of the patient. This includes such points as resentment at the injury, apathy, desire for compensation, fear of pain, keenness to get well, or other motives inspiring the desire for treatment.

He should also seek to realize the patient's environment and, if desirable, suggest a change to a nursing home or other suitable place. The attitude of the patient's wife and friends must not be forgotten, nor that of the employer and of the insurance company. These factors may, if not considered, seriously militate against recovery.

Considered attempts must be made for the development of a feeling of sympathy (on the part of those giving the treatment) for the injured person; it is also essential that they should gain his confidence in themselves and in the methods and apparatus used. His intelligent co-operation must be gained in all the therapeutic measures used, both during the period of active treatment and (perhaps still more important) during the quiescent periods between sessions.

The discreet use of direct mental measures is also an important factor; this includes such steps as threats for the indifferent, encouragement for the pessimistic, warnings for the lazy, discipline for the malingerer, etc.

Among other methods that assist the mental side of things may be mentioned the following: giving exact instructions, written, if possible, as to self-treatment, correct movements,

diet, exercise, etc., between treatments; a careful record of progress—particularly of joint movements—by photographs or goniometers (instruments which indicate in degrees the amount of flexion); the exhibition to the patient of other cases being benefited by similar measures, and also of those actually cured.

On the part of the attendant masseur (or masseuse), there needs to be a good general knowledge of human nature as well as of anatomy, so that he can appreciate the patient's feelings, realize his mentality, and patiently persevere in all the minute processes that go to bring about a cure.

General Physiotherapy

The general health and habits of the patient need careful consideration and supervision. The possible presence of such deterrents to speedy recovery as diabetes, scurvy, constipation, alcoholism, venereal disease, and septic foci, needs to be constantly borne in mind. Special emphasis should be laid on the "toilet of the mouth" and the exclusion of pyorrhea, root abscesses, and the like.

It is clear that the proper co-ordination of all the foregoing forms of treatment calls, at any rate in the more chronic and complicated cases, for the experience and advice of a specialist, but much can be done toward the rehabilitation of many patients by the use of the simpler forms of physiotherapy under the care of an ordinary practitioner.

Summary

Study and Co-ordination

A careful study of the plant, of the staff, and of general working conditions is a necessary preliminary to efficient results. Records of accidents, their causes and their results need to be kept and considered. Thorough co-ordination between the management and the medical department is an important factor.

Prevention of Accidents

Organized "safety first" is of the utmost value in every industry. This includes the keeping of all laws and regulations made for the prevention of accidents, and inquiry into accidents that do occur, with due punishment for infractions of the law. It also involves the education of workers in the principles of the safety movement and the encouragement of the workers by all reasonable means.

Other points of administration have been dealt with in detail in that section of this article.

Organization of First Aid

Organization of first aid is a necessary corollary of prevention, for, notwithstanding the most carefully planned prevention, accidents are bound to occur. The first-aid department must be made popular with the management and with the rank and file of the workers; all injuries must be notified to the medical department; suitable transport, and an efficient staff, must be provided; modern equipment and dressings must be supplied; quarters that are clean and accessible must be arranged; and the whole department personally supervised by the medical officer.

Treatment

Surgical.—Suitable provision needs to be made for the further treatment

of patients who are not sufficiently disabled to discontinue work but who have an injury which needs dressing.

The services of skilled workers should be immediately and continuously available for the treatment of all serious injuries. This, in any large works, involves the provision of a proper ward or wards, the presence of a whole-time qualified surgeon and of trained nurses.

Proper and up-to-date facilities for diagnosis must be provided, such as a local or centrally accessible X-ray department. The close personal supervision of the treatment given in the wards such as dressing, stitching, and splinting is also called for. Modern surgical technic in operative procedures is a necessary item in the whole scheme.

Physical.—A properly organized physiotherapeutic department forms an essential part of the medical side of any large industry which is up-to-date in its methods and progressive in its ideas. Suggestions for the conduct and control of such a department are made under the proper section of this paper; no hard and fast rules can be laid down, except that if such treatment is to be given it must, for effective results, be administered by people who have received special training in such work, and that the appliances used must be those which have definitely proved to be of use in similar institutions.

Conclusions

1. It must be increasingly recognized by those at the head of large industries that a fully equipped medical department, where all modern methods of surgery and rehabilitation are possible, is an essential part of a properly organized concern, and forms a sound financial investment.

2. The possibility exists for smaller firms to combine (either by a central fund or mutual insurance) in order to maintain a rehabilitation center for the purpose of treating disabled employees. Insurance companies might also make some such arrangement for the treatment of accidents happening to other than industrial workers.

From every point of view, humanitarian, economic, financial, and scientific, it is abundantly clear that some such plan as outlined is both necessary and possible, and that by a well-conceived organization and close attention to detail a successful issue may be guaranteed.

Bibliography

1. Department of Mines and Industries, South Africa. Statistics Report.
2. Wilson, H. M., and Fleming, J. R.: Organizing and Conducting Safety Work in Mines. U. S. Bur. Mines, Tech. Paper 103. Washington, Government Printing Office, 1917.
3. Collis, E. L., and Greenwood, M.: The Health of the Industrial Worker. Philadelphia, P. Blakiston's Son & Co., and London, J. & A. Churchill, 1921.
4. 9,500 Partially Disabled Employees Working in Ford Motor Plant. Nat. Safety News, 1921, *3*, No. 3, p. 5; abstr. in This Jour., 1921–1922, *3*, 89.
5. Gibbons, M. R.: Return to Work after Injury. Calif. State Jour. Med., 1921, *19*, 458; abstr. in This Jour., 1922–1923, *4*, 38.
6. Injuries and Diseases of War. R. A. M. C. Manual.
7. Reports of the Special Investigation

Committee on Surgical Shock and Allied Conditions. VIII. Traumatic Toxaemia as a Factor in Shock. Med. Res. Comm., Spec. Rep. Series No. 26. London, H. M. Stationery Office, 1919.

8. Douglas, S. R., Fleming, A., and Colebrook, L.: Studies in Wound Infections. Med. Res Council, Spec. Rep. Series No. 57. London, H. M. Stationery Office, 1920.
9. Heald, C. B.: The Early Treatment of Fractures. Brit. Med. Jour., 1924, *1*, 743.
10. Thompson, H. F. Q.: Knee-Joint Injuries. Proc. Transvaal Mine Medical Officers' Assn., Sept., 1924.
11. Pickerill, H. P.: Facial Surgery. New York, William Wood & Co., and Edinburgh, E. & S. Livingstone, 1924.
12. McKendrick, A.: Back Injuries and their Significance under the Workmen's Compensation and Other Acts. Edinburgh, E. & S. Livingstone, 1916.
13. Jones, A. B., and Llewellyn, L. J.: Malingering or the Simulation of Disease. London, W. Heinemann, 1917.
14. Collie, J.: Malingering and Feigned Sickness. New York, Longmans, Green & Co., and London, Edward Arnold, 1917.
15. Camus, J.: Physical and Occupational Re-education of the Maimed. Translation. New York, William Wood & Co., 1919.
16. Kerr, J. R.: The Physiotherapy Treatment of Industrial Accident Cases. Jour. State Med., 1923, *31*, 467.
17. Luke, T. D.: Manual of Physiotherapeutics. London, W. Heinemann, 1922.
18. Fox, R. F.: Physical Remedies for Disabled Soldiers. London, Baillière, Tindall & Cox, 1917.
19. Rollier, A.: Heliotherapy. London, Hodder & Stoughton, 1923.
20. Cotton, F. J., and Sawyer, E. J.: Stiff Fingers. Boston Med. and Surg. Jour., 1922, *186*, 183.
21. Mennell, J. B.: Massage. Its Principles and Practice. London, J. & A. Churchill, 1917.
22. Morrell, R. A.: The After-Effects of Certain Industrial Injuries and their Treatment by X Rays. Brit. Med. Jour., 1923, *2*, 460.

BOOKS RECEIVED

Books received are acknowledged in this column, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers and as space permits.

International Clinics. Volume II. Thirty-Fifth Series, 1925. Cloth. Pp. 311 with illustrations and index. Philadelphia and London: J. B. Lippincott Company, 1925.

An Epoch in Life Insurance: A Third of a Century of Achievement. Thirty-Three Years of Administration of the Metropolitan Life Insurance Company. By *Haley Fiske*, President, *Raymond V. Carpenter*, Actuary. Second Edition. Cloth. Pp. xxxviii, 306 with index. New York, December 31, 1924.

Rats and How to Destroy Them: Dealing with Rats in a House, Shop, Warehouse, Outbuilding, Yard, Stable, Cow-House, Fowl-House, Pig-Sty, Garden, Greenhouse or Vinery; by a River, Stream or Ornamental Water; on a Ship, Shooting Estate, or Farm; and in Sewers. By *Mark Hovell*, F.R.C.S., with an Introduction by *S. L. Bensusan*. Cloth. Pp. xlii, 465 with index and illustrations. New York: William Wood and Company, 1924.

Preventive Medicine. By *Mark F. Boyd*, M.D., M.S., C.P.H., Member of Regular Field Staff, International Health Board of the Rockefeller Foundation; formerly Professor of Bacteriology and Preventive Medicine in the Medical De-

partment of the University of Texas. Second Edition, Revised. Cloth. Pp. 429 with illustrations and index. Philadelphia and London: W. B. Saunders Company, 1925.

PERSONAL AND COMMUNITY HEALTH. By *Clair Elsmere Turner*, Associate Professor of Biology and Public Health in the Massachusetts Institute of Technology; Associate Professor of Hygiene in the Tufts College Medical and Dental Schools; Sometime Member of the Administrative Board in the School of Public Health of Harvard University and the Massachusetts Institute of Technology; Fellow American Public Health Association; Major, Sanitary Corps, U. S. A. (Reserve). Cloth. Pp. 426 with index and illustrations. St. Louis: The C. V. Mosby Company, 1925.

BOOK REVIEW

THE CONQUEST OF CANCER. By *H. W. S. Wright*, M.S., F.R.C.S. With an Introduction by *F. G. Crookshank*, M. D., F.R.C.P. Cloth. Pp. 82. New York: E. P. Dutton and Company, 1925.

This little book by Dr. Wright is interestingly written and engages the attention of the reader from beginning to end. Dr. Wright's main thesis is that the conquest of cancer cannot come about to any appreciable degree until the public is sufficiently enlightened as to the nature of cancer and as to the fact that early recognition of incipient cancer plus surgical removal are required if cancer is not finally to kill its victim. He advises that no chances should be taken, and that where any doubt exists careful study plus examination of bits of tissue should be made. Dr. Wright quotes statistics from his actual practice which suggest the practical value of his thesis.

There is an introduction by Dr. Crookshank which is not only interesting but informative and should also be read.—*Henry B. Elkind.*

THE OXYGEN-CARBON DIOXIDE TREATMENT OF CARBON MONOXIDE POISONING: COMMUNICATION FROM DR. J. S. HALDANE

Cherwell,
Oxford.
November 30, 1925.

My dear Professor Drinker,

In view of doubts which have been expressed as to the advantages, in the first-aid treatment of carbon monoxide poisoning, of adding about 5 per cent. of carbon dioxide to the oxygen used, as recommended by Yandell Henderson and Haggard, you have asked me to express an opinion on the subject.

I wish to say at once that I am strongly in favour of the carbon dioxide admixture. Not only does the carbon dioxide, by increasing greatly the depth of breathing, hasten in corresponding degree the elimination of carbon monoxide from the blood, but the carbon dioxide itself gives marked immediate relief to the anoxaemia. It does so by enabling the circulation, kept in check by the alkalosis produced by increased breathing of carbon monoxide poisoning, to increase at once, thus carrying much more oxygen to the tissues. In a recent paper[1] I described a series of experiments on animals where this relief was strikingly demonstrated, and I showed that in cases where, as at underground fires in mines, it is difficult to provide sufficient quantities of the oxygen-carbon-dioxide mixture, a mixture of carbon dioxide and air may be used with great advantage, since a small cylinder of liquid carbon dioxide will provide a very large quantity of the mixture. The mixture of carbon dioxide and air is, I think, superior to pure oxygen, though inferior to the mixture of oxygen and carbon dioxide.

I remember well how disappointed I was, about thirty years ago when I tried on myself the effects of pure oxygen when I was on the point of losing consciousness during experimental carbon monoxide poisoning.[2] At that time I had of course no conception of the importance, or even the existence, of the alkalosis of carbon monoxide poisoning. The experiments of Henderson and Haggard brought this factor to light, and at once the whole subject was illuminated. Their inferences fitted in with a number of other facts relating to alkalosis in anoxaemia and to the regulation of the circulation.

I feel no doubt that further experience will fully confirm the advantages of adding carbon dioxide in the non-toxic proportion of about 5 per cent. to the oxygen or air used in first-aid to cases of carbon monoxide poisoning or temporary anoxaemia produced by methane or other physiologically indifferent gases.

Yours very sincerely,
J. S. HALDANE.

[1] *Tr. Inst. Min. Eng.*, 1924, *68*, 271.
[2] *Jour. Physiol.*, 1895, *18*, 458.

J. I. H.
Jan., 1926